

project  
**mercury**

# HF RADIO POINT-TO-POINT COMMUNICATIONS

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WESTERN ELECTRIC COMPANY, INC.

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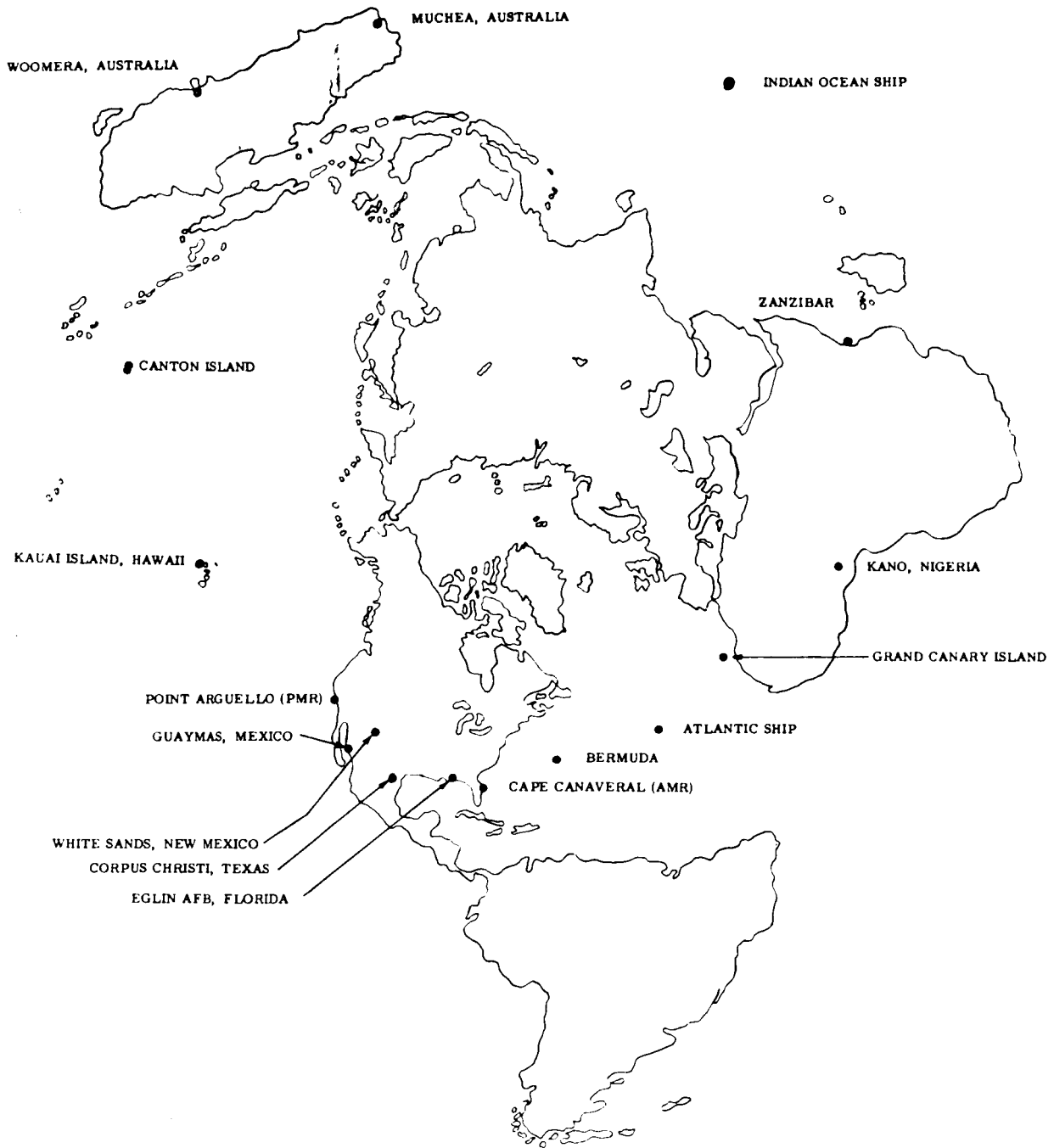
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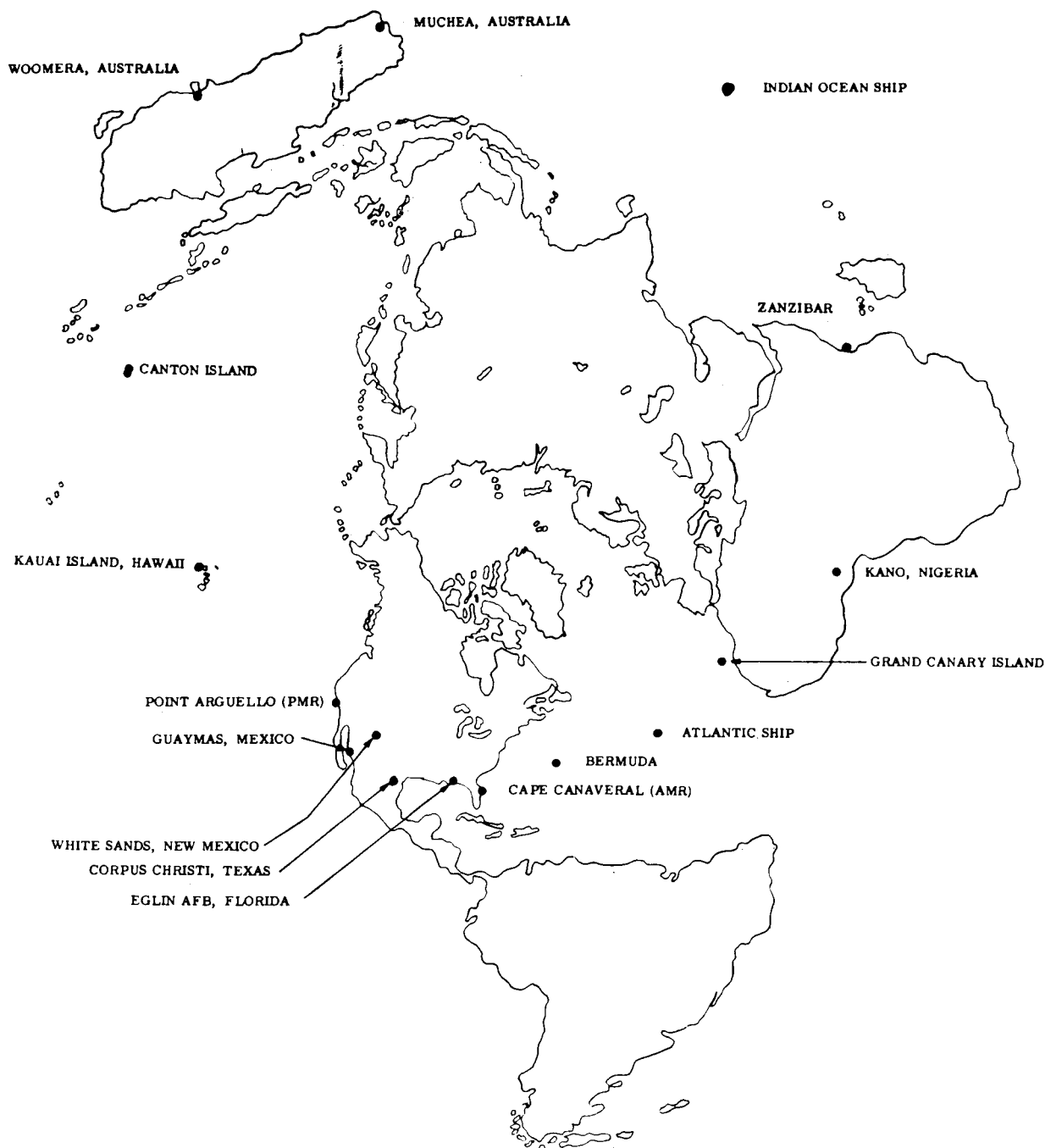
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## SECTION 1. DESCRIPTION

### 1.1 GENERAL INFORMATION

#### 1.1.1 Scope of Manual

This manual contains information required to operate and maintain the HF radio point-to-point communications system for periods other than during orbital flight. The information included applies to the HF radio transmitting, receiving, and associated equipment.

Procedures to be followed during orbital flight are covered in MO-101R, *Remote Site Operations Procedures*. Check lists, to be used prior to a mission, are shown in Section 6 of this manual.

The HF radio point-to-point communications system, as designed, employs radio links to carry teletype communications between certain remote sites in the Mercury ground instrumentation complex and the leased cable and radio facilities to the Goddard Space Flight Center (GSFC) and Mercury Control Center. The sites using HF radio links are Kano, Zanzibar, and Atlantic and Indian Ocean Ships. The complete ground communications circuit layout is shown in Figure 1-1. The HF radio circuit layout is shown in Figure 1-2.

The circuits derived from these HF radio links will be full duplex teletype and teletype order wire circuits. These circuits will carry acquisition, command, and administrative traffic outward to the remote sites. They will also carry tracking, telemetry summary, and administrative traffic to the Goddard Space Flight Center and the Mercury Control Center. The order wire circuits will be used for system lineup traffic and system maintenance.

#### 1.1.2 System Characteristics

The HF radio link is a practical means of connecting outlying sites to the Mercury ground communications complex when wire or submarine cable circuits are not available. HF

radio circuits, however, are subject to unstable periods. To ensure a minimum effect from these periods, the following technological advances are used:

- a. Single sideband mode of transmission.
- b. Space diversity reception (land installations).
- c. Polarization diversity reception (ship installations).
- d. Frequency diversity operation in the audio tone multiplexing system.

In point-to-point HF communications, the prime concern is radio wave propagation at frequencies in the 3.0- to 30.0-mc range. At these frequencies, the ground wave attenuates rapidly and is of no importance except at very short distances. All long distance communication is by sky wave which is reflected from the ionosphere. The ionosphere consists of rarefied ionized air and, depending on its free electron density, will reflect or absorb radio waves. Of the several layers in the ionosphere, the F2 layer is the principal reflecting region for long distance HF signals. The maximum usable frequency (MUF) depends on the length of the path and the height and electron density at the point or points of reflection of the sky wave in the ionosphere. The MUF changes are effected by the sun spot cycle and the month to month changes in height of the F2 layer. The National Bureau of Standards (NBS) issues MUF information. Predications are made 1 hour in advance on a short term basis. On a long term basis, they are made 3 months in advance. The optimum operating frequency is usually 15 per cent below the MUF. However, the upper and lower frequency limits change continuously throughout the day. The higher frequencies (10 to 30 mc) are best during the day and the lower frequencies (3 to 10 mc) are usually best at night. In point-to-point HF communication, directive

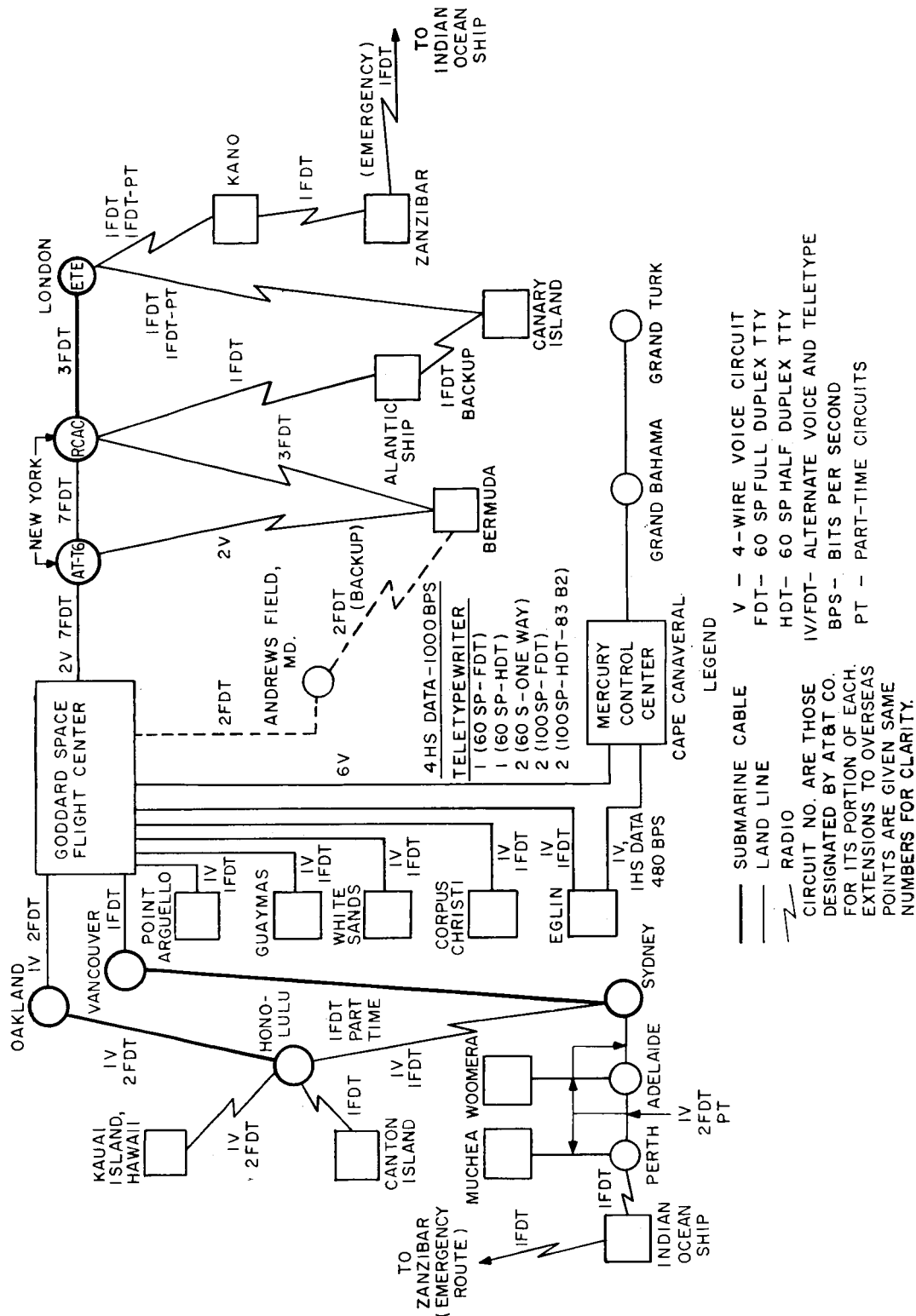


FIGURE 1-1. MERCURY GROUND COMMUNICATIONS LAYOUT

transmitting antennas with a low angle of radiation (5 to 15 degrees) should be used. This antenna should direct the energy over the great circle path with the fewest number of reflections (hops) between the transmitter and receiver.

Information must be converted to a code or set of symbols for transmission. The information carried on the Mercury ground communications system will be in the form of teletype pulses. These pulses must undergo further transformation in the form of modulation to adapt them to the transmission medium, which, as covered by this manual, is HF radio. The teletype coded signals can be used to turn the HF radio (RF carrier) off and on (CW), shift the frequency of the RF carrier (FSK), or amplitude modulate the RF carrier (am).

There are advantages and disadvantages to each of these methods. The CW method does not use bandwidth and power efficiently, as each information channel requires the use of an RF carrier and two sidebands of the carrier are produced. One sideband and the carrier cannot be completely eliminated and still be a satisfactory mode of transmission.

The FSK method has long been used for transmission of teletype signals and has an advantage in that the equipment used is insensitive to amplitude variations. It thus provides a better signal-to-noise advantage over AM transmission methods of the same bandwidth.

The AM method of transmission creates a steady carrier plus two sidebands, each of which contains all the intelligence. As an example, if a 9.0-mc RF carrier is modulated by a 1.0-kc tone,

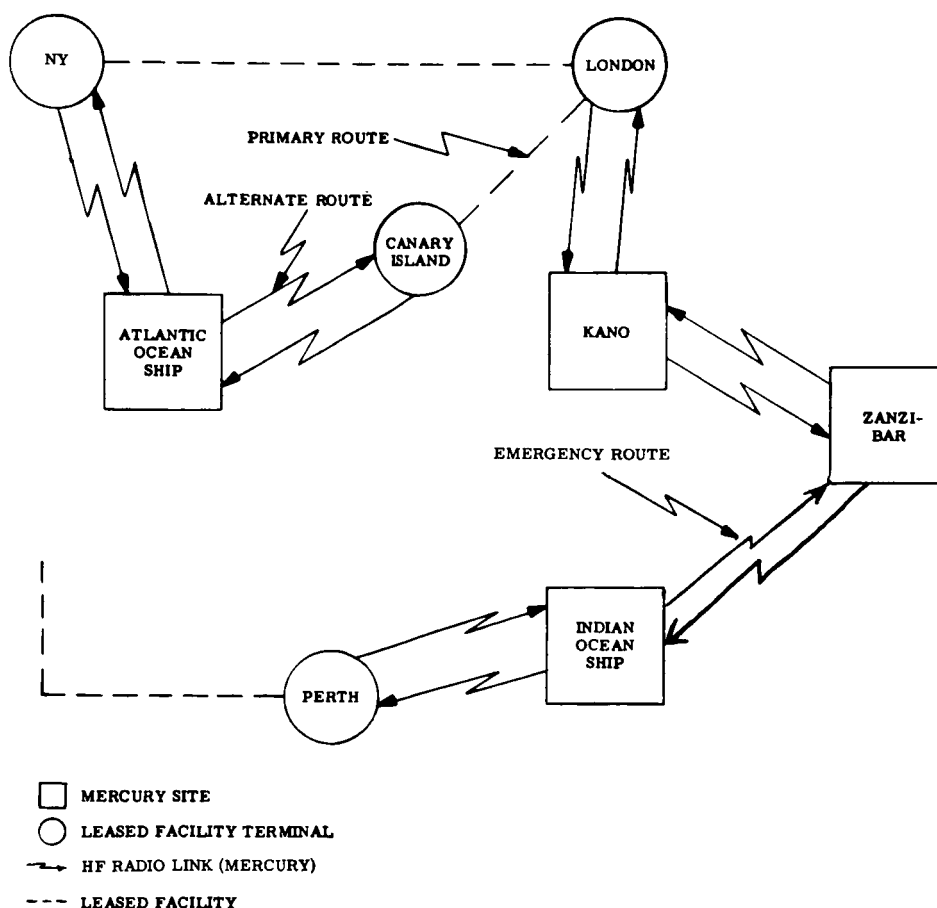


FIGURE 1-2. HF RADIO, CIRCUIT LAYOUT

the resultant products of this modulation would be:

Carrier: 9.0 mc

Tone: 1.0 kc

Carrier + Tone: 9.001 mc (USB)

Carrier - Tone: 8.999 mc (LSB)

If the 1.0-kc tone was further shifted in frequency by the mark and space teletype signals, from 950 to 1050 cps, the sidebands shown above would be as follows:

Carrier + Tone: 9.000950 to 9.001050 mc (USB)

Carrier - Tone: 8.998950 to 8.999050 mc (LSB)

The intelligence (tone frequency shifted by mark and space teletype signals) is contained in each of the sidebands. As no intelligence is contained in the carrier, there is no need to transmit it. However, it must be reinserted accurately at the receiver. Since the same information is contained in both upper and lower sidebands, it is necessary to transmit only one sideband to deliver all the information to the distant terminal. The carrier can be suppressed by using a balanced modulator, and the desired sideband can be chosen by use of filters. The modulators and filters are further discussed in paragraphs 2.1.2 and 2.1.3 of this manual.

The single sideband system allows a major saving in transmitter power, and the signal-to-noise ratio at the receiver will remain the same at this reduced transmitter power. The narrower bandwidth used in this mode will result in an improved signal over the FSK mode of transmission. Interference problems are reduced by the use of a narrower portion of the spectrum and can be further reduced by the ability to put the intelligence on either of the two sidebands.

The space diversity technique takes advantage of the fact that signals received at different locations do not fade synchronously. It has been determined that in the HF range, if antennas are spaced 3 to 10 wavelengths apart, the signal received at each antenna will fade independently. In a space (dual) diversity system, two antennas and two receivers are used with a com-

mon output. A common bias voltage, derived from the sum of the receiver output voltages, is used in the combining operation. The channel with the best signal will predominate and the other channel will contribute little or nothing to the output.

A frequency diversity system also takes advantage of the fact that signals of slightly different frequencies do not fade synchronously. This applies favorably in the radio-teletype tone multiplexing mode of transmission. A teletype signal may be used to key two audio tone channels simultaneously and the best frequency is selected at the distant terminal to operate the teletype equipment.

Polarization diversity contributes to the reliability of the HF communications link. Vertically and horizontally polarized waves will be attenuated differently by conditions encountered in HF propagation. The polarization of a sky wave is altered by reflection from the ionosphere and may be received on either a vertically or horizontally polarized receiving antenna. The polarization of the transmitted wave refers to the relation of its electric field with respect to the earth's surface. For any angle of radiation, the magnitude of the reflected wave will be less when the signal is vertically polarized. Static, and other noise, has less effect on the horizontally polarized wave. The field strength versus height and field strength versus distance curves show less depth of fade with vertical polarization, over the same path as a horizontally polarized signal. Ground absorption is more critical with horizontal polarization.

## 1.2 DESCRIPTION OF SYSTEM

### 1.2.1 General Description

HF radio links are provided with terminal equipment at the Atlantic Ship, Kano, Zanzibar, and Indian Ocean Ship. Terminal equipment has been furnished to the leasing agencies at the Canary and Canton Islands. This equipment is needed to provide Mercury lease requirements. This equipment will be maintained and operated by Transradio Española and the Federal Aviation Agency (FAA) personnel, respectively. It will not be covered further in this manual.

The receiving terminal equipment consists of antennas, multicouplers, filters, diversity receivers, and tone multiplexing equipment. The transmitting equipment consists of antennas, coaxial patch panel, filters, single sideband transmitters, mode selectors, and tone multiplexing equipment. The intrasite link between the receiver and transmitter locations, at Zanzibar, is a UHF system. It consists of UHF transmitters, receivers, diplexer, paraflector antenna, and channelizing equipment. An alternate route to London will be established via UHF from the Mercury receiver area to Zanzibar City and then on to London over Cable and Wireless facilities. A buried cable will be used as an intrasite link at the Kano site. (See Figure 1-3.)

### 1.2.2. Physical Description

The transmitting and receiving antennas at Kano and Zanzibar are rhombics. Each consists of four, long wire radiating elements arranged in the shape of a rhombus (an equilateral parallelogram having its angles oblique) and 375 feet per leg. This antenna is shown in Figure 1-4 and is a three-wire curtain antenna. At Zanzibar, two receiving and one transmitting, steerable log periodic antennas are provided. They are horizontal broad band, unidirectional, beam antennas (LPA 728-A).

The antenna systems on the ships are discone/cage type for transmitting and a polarization diversity combination of a conical monopole and horizontal cage type for receiving. The discone/cage antenna extends approximately 33 feet above its pedestal. It consists of a wire array of 19 feet at the top and 14 feet at the bottom. The wide point is at the junction of the top and bottom arrays. This antenna is illustrated in Figure 1-5. The diversity combination of vertical and horizontal receiving antennas is illustrated in Figures 1-6 and 1-7. All the antennas (HF) are covered in detail in MS-121, *Outside Plant*, under transmission lines and antennas.

The receiving equipment consists of individual units mounted in equipment racks with the racks positioned to form bays. The equipment bay lineup will vary depending on the number of links terminating at a particular site.

Floor plan and face equipment drawings have been provided for each site and should be consulted. These drawings are indexed in Section 5 of this manual.

Figure 1-8 shows a typical rack layout at a site with one receiving terminal and spare equipment. Figure 1-9 shows the cross connection of the DDR-6 units. At sites where there are two receiving terminals and spare equipment or four terminals, as at Kano, the racks will be increased accordingly.

A typical multiplex equipment layout is shown in Figure 1-10. The teletype equipment (Figure 1-8) may be installed in an additional bay to obtain separation from the RF patching equipment to reduce noise pickup in the receiving system.

The GPT10K-H single sideband transmitter is cabinet enclosed and constructed on two basic frames (main and auxiliary). Figures 1-11 and 1-12 show typical frame and unit arrangements for a single transmitting terminal. The number of transmitters will vary from two to four at the different sites with additional rack space as required for control and miscellaneous equipment. A detailed physical description of each unit is given in the equipment manual for the respective equipment unit.

### 1.2.3 Functional Description

The receiving antenna arrays at Kano and Zanzibar are arranged for space diversity reception. Transmitting antennas at these sites are designed to ensure that a maximum amount of RF energy will be radiated toward the distant terminal. The increased gain, directional properties, and broad frequency response of the rhombic antenna will ensure more reliable communications. Due to space limitations on the Atlantic and Indian Ocean Ships, the discone/cage antenna is used to radiate the RF energy and a polarization diversity combination (conical monopole and horizontal cage) is used for reception of the signals from the distant terminal. The log-periodic steerable antennas at Zanzibar will be used to establish an emergency route for Indian Ocean Ship communications. Antenna functions are covered in detail in MS-121, *Outside Plant*, under transmission lines and HF antennas.

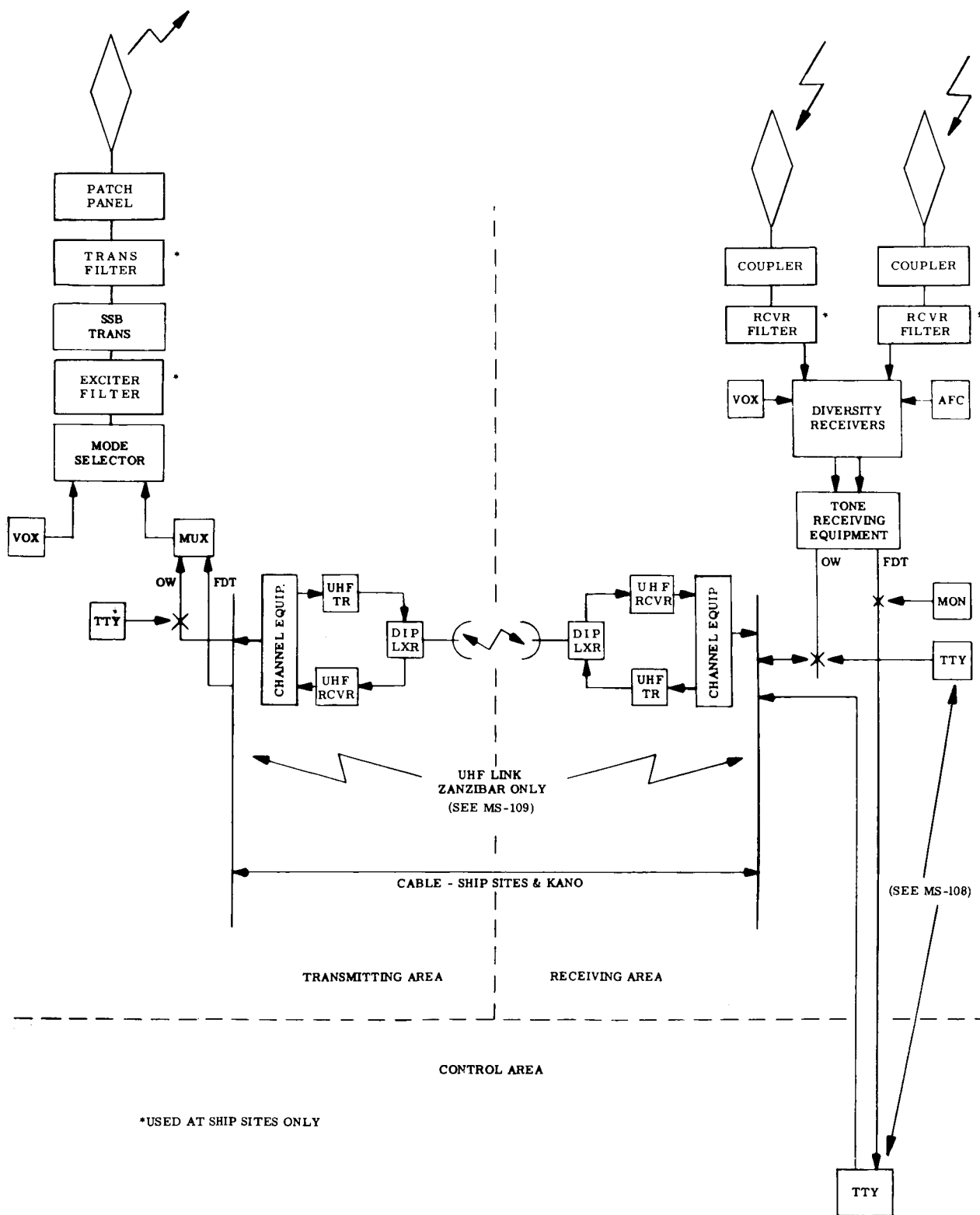


FIGURE 1-3. HF SYSTEM, BLOCK DIAGRAM

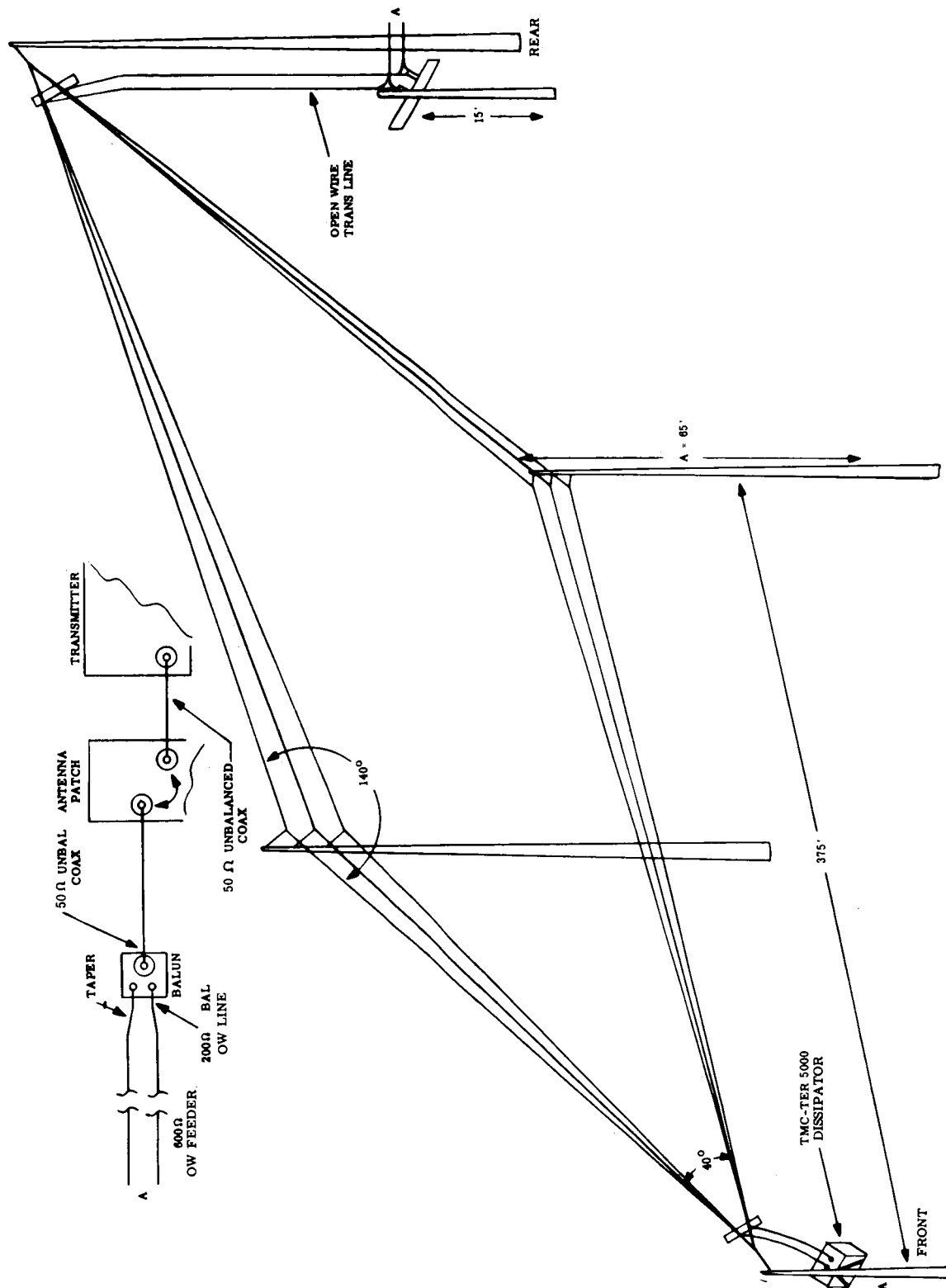


FIGURE 1-4. RHOMBIC ANTENNA

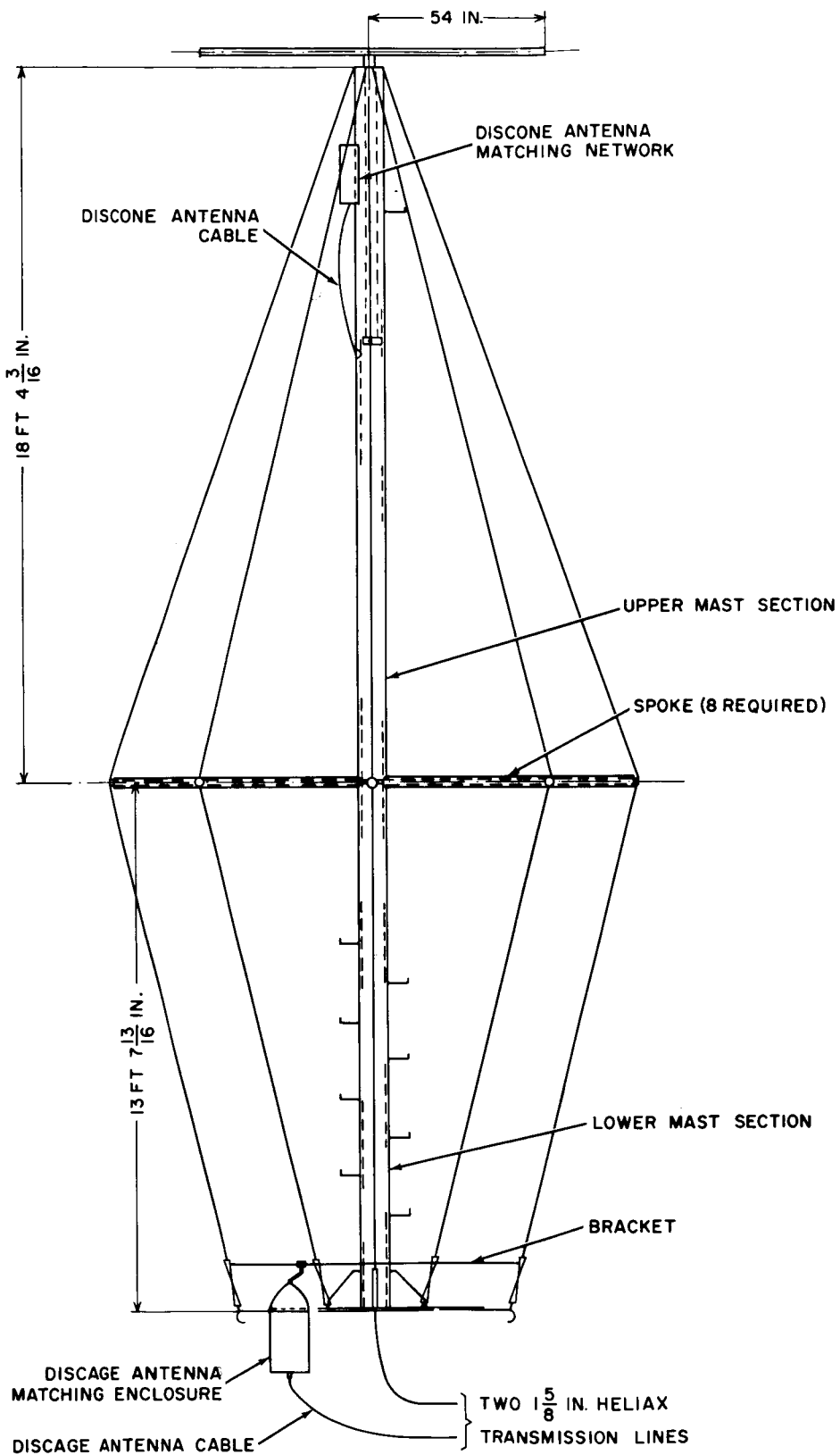


FIGURE 1-5. SHIPBOARD TRANSMITTING ANTENNA

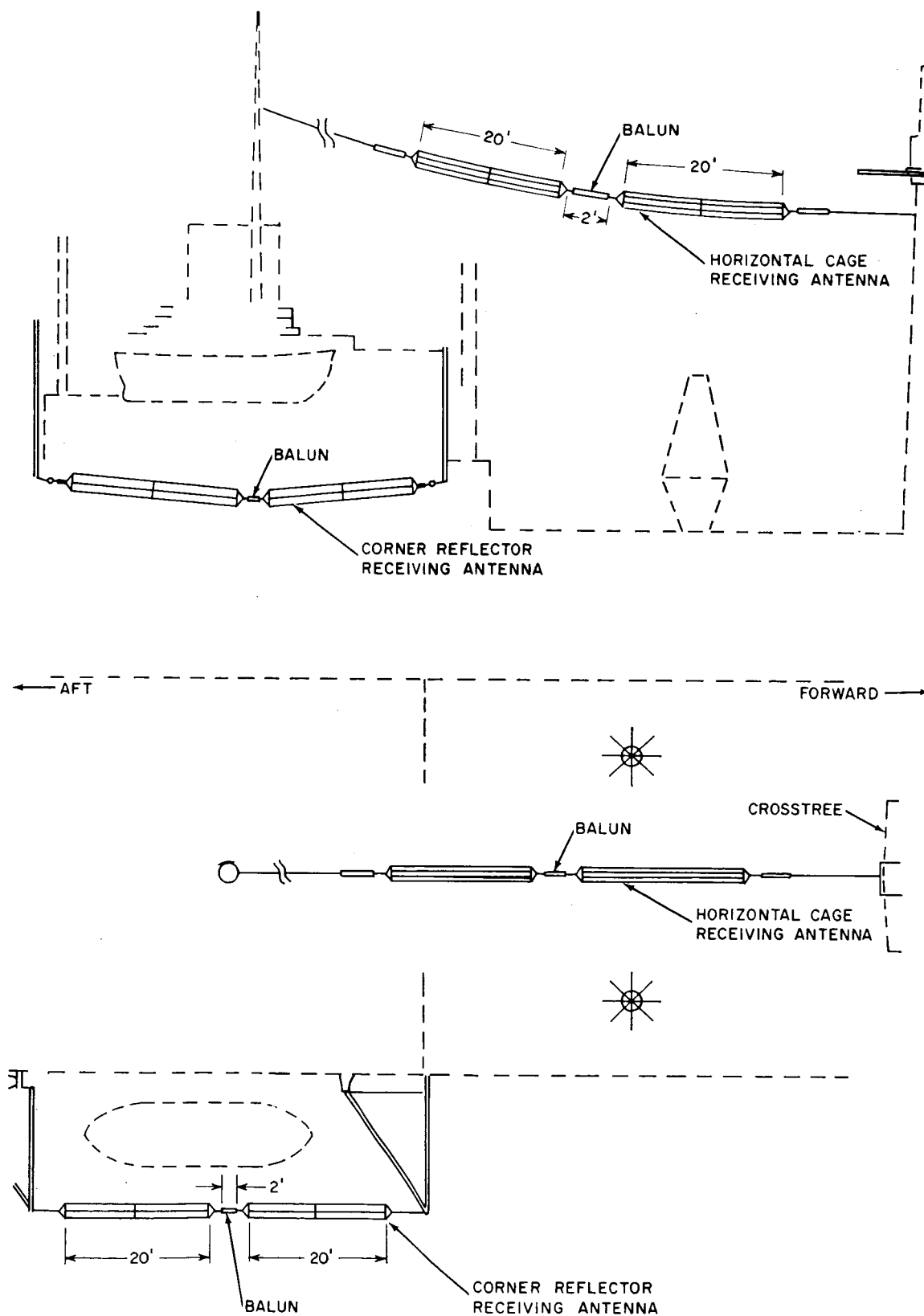


FIGURE 1-6. SHIPBOARD RECEIVING ANTENNA, HORIZONTAL TYPES

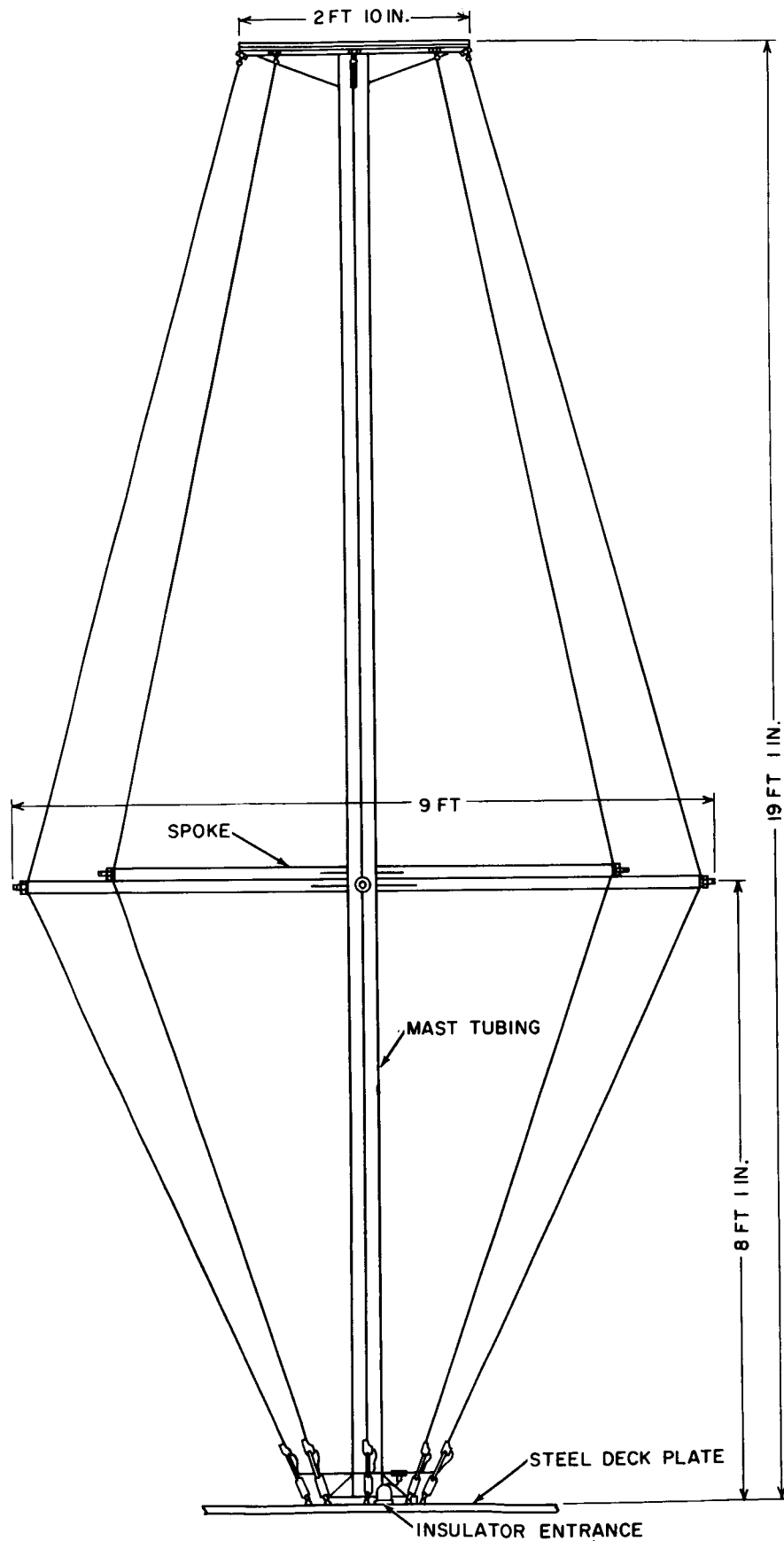


FIGURE 1-7. SHIPBOARD RECEIVING ANTENNA, CONICAL MONOPOLE

LSP-7	LSP-7	FUSEBOARD
AFC	AFC	63CI TTY LOOPBOARD
MSR-6	MSR-6	RF PATCH ASSEM QDP-38
		ANT. COUPLER (HFD-6)
		ANT. COUPLER (HFD-6)
GPR-90RX	GPR-90RX	RF PATCH ASSEM QDP-38
		AUDIO AND DC EQUIPMENT PATCH
I.F. PATCH (BNC)	I.F. PATCH (BNC)	
VOX-3	VOX-3	
GPR-90RX	GPR-90RX	MISC RELAY RACK EQUIP SUCH AS: LYNCH TTY REPEATERS AND/OR TTY RECTIFIERS (SEE PAR 1.2.2)
MSR-6	MSR-6	
AFC	AFC	
SEE FIG. 1-9 FOR CROSSCONNECTION OF UNITS IN THIS BAY		
P/S	P/S	
REG	SPARE	AUX

FIGURE 1-8. TYPICAL RECEIVING LAYOUT

The single sideband transmitter radiates 10-kw peak envelope power (PEP) in the frequency range of 4 to 28 mc. The transmitting mode selector is the exciter in this single sideband (SSB) system. Its output drives the linear 10-kw RF amplifier. When required, a variable oscillator is employed to supply a highly stable

master oscillator frequency. The frequency shift tone equipment converts dc teletype pulses to audio tones for insertion in the sideband converting equipment. The frequency shift tone equipment (multiplexing) is used as a means of increasing the number of channels per SSB system.

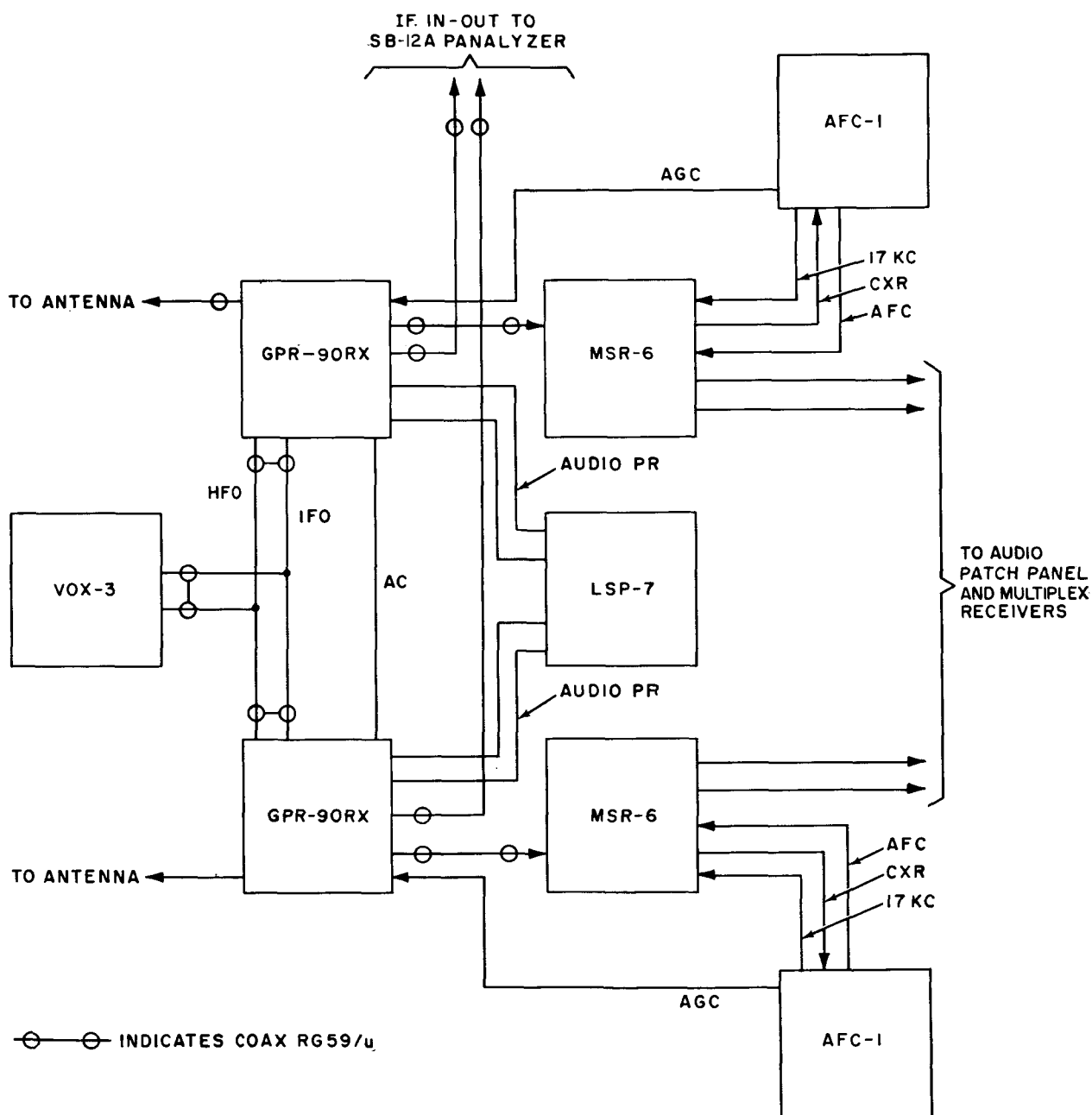


FIGURE 1-9. DDR-6 UNITS, CROSS CONNECTION

The received signals pass from the antenna array and antenna multicouplers, through receive filters at ship sites, to the DDR-6 diversity receiving unit. This unit contains dual diversity SSB receivers and mode selectors. The necessary HF and IF oscillator signals are supplied by the variable frequency oscillator (VOX). Audio tones from the DDR-6 unit are converted to dc in the tone receivers and combiner, and the dc signal is supplied to the teletype equipment. An AFC modification unit introduces frequency stability and improves the AGC of the receiver.

The transmitting locations at the Zanzibar and Kano sites are 4 to 6 miles from the control area and receiving locations. At Zanzibar, a UHF link is used to span this distance and multiplexing equipment is used to develop three voice channels (PBX trunk, control OW, and radio OW) and two teletype channels. At Kano, approximately 4 miles of 19-gauge cable is used and the dc teletype signals are sent directly over the cable.

The above circuitry is further described in Section 2 of this manual.

### 1.3 INDEX OF EQUIPMENT SUPPLIED

The equipment supplied at the Kano, Zanzibar, Atlantic Ship, and Indian Ocean Ship sites are of the same in type but vary in number. The variation in number is dependent on the number of links terminating at a site and the number of spare equipment supplied.

The links involved are as follows:

<i>Site</i>	<i>No. of Links</i>	<i>Circuits To</i>
Kano	2	London Zanzibar
Zanzibar	2	Kano Indian Ocean Ship
Atlantic Ship	2	Canary Island New York
Indian Ocean Ship	2	Perth Zanzibar

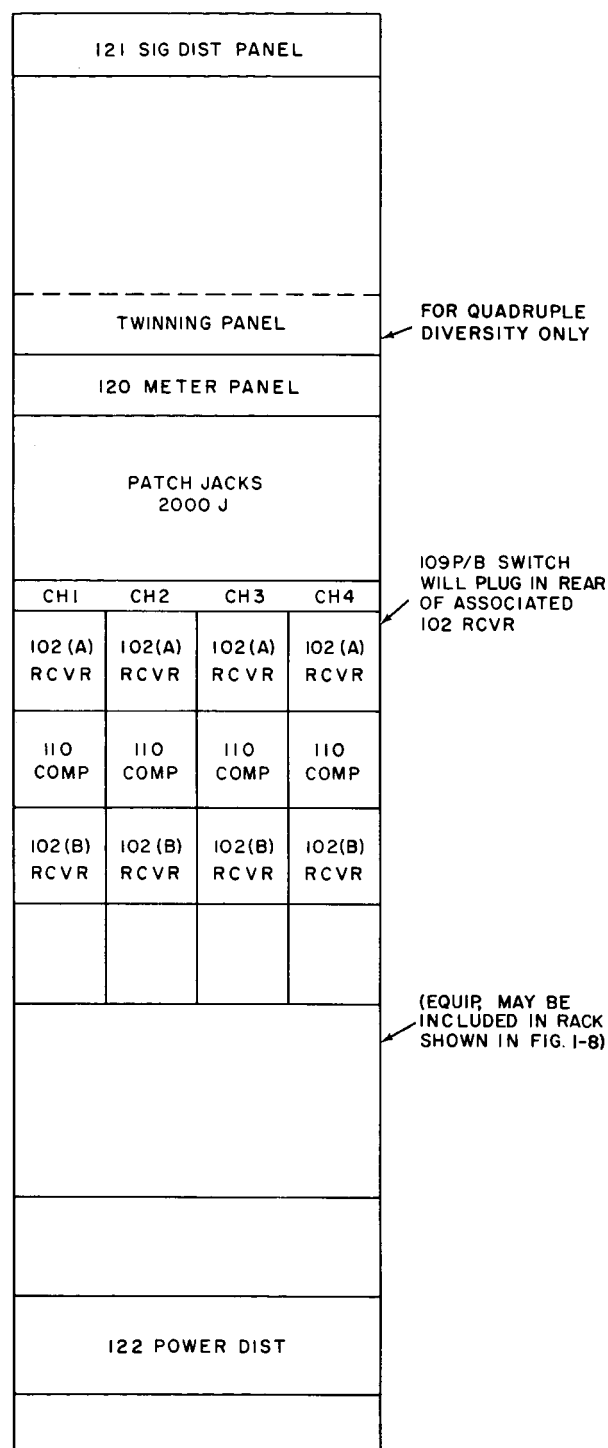


FIGURE 1-10. TYPICAL HF RECEIVING LAYOUT, MUX EQUIPMENT

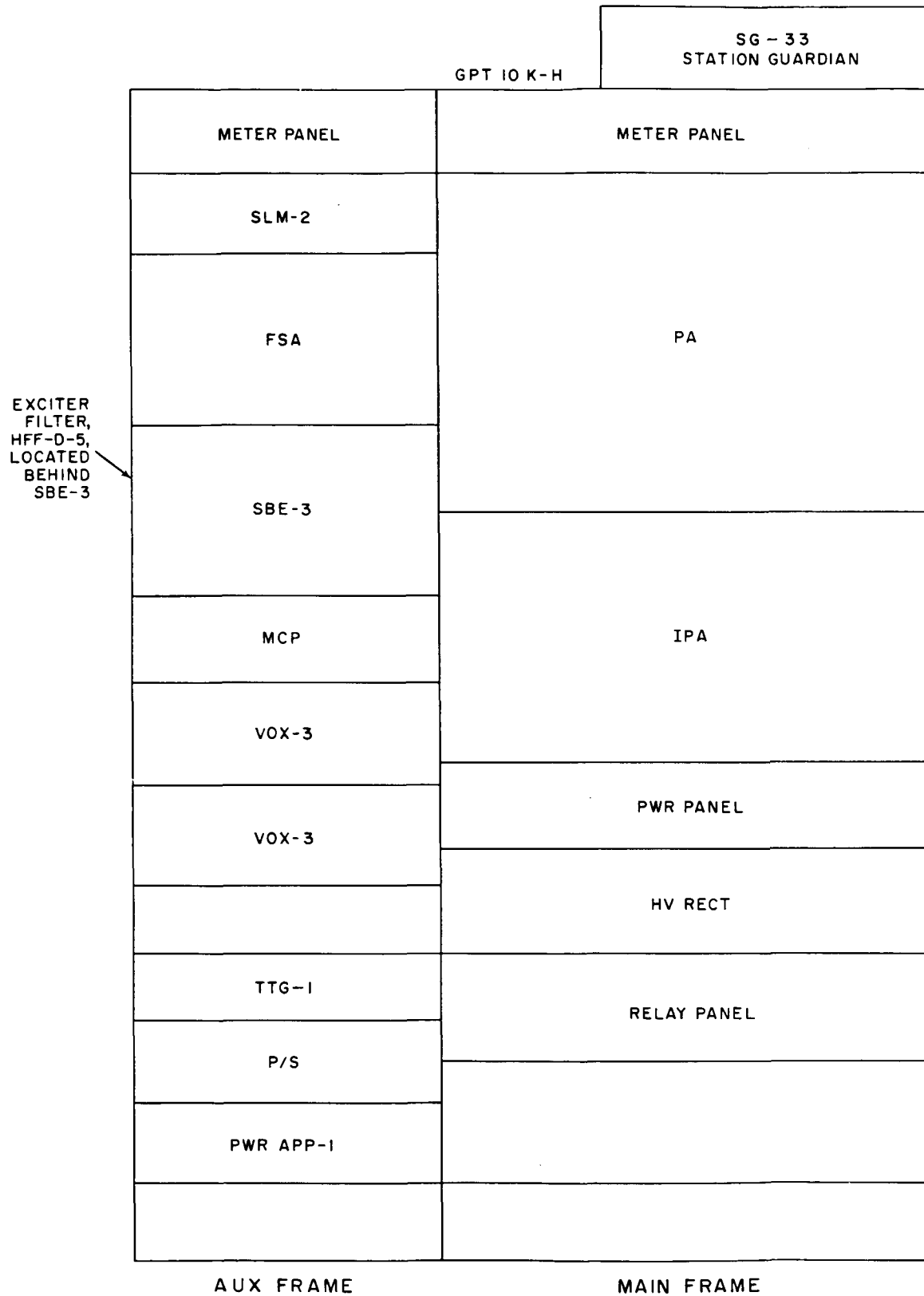


FIGURE 1-11. TYPICAL HF TRANSMITTING LAYOUT

These links are shown on Figure 1-2 of this manual. The equipment items at each site are listed in Table I. The units of each major equipment item are indexed in Table II (transmitter), Table III (receiver), and Table IV (multiplex) which follow. The uhf intrasite link equipment supplied at Zanzibar is indexed in Table V. The Zanzibar UHF radio equipment is described in MS-109, *Intrasite PBX and Intercom*.

#### 1.4 INDEX OF EQUIPMENT MANUALS

Table VI is a list of the equipment manuals for the receiving and transmitting units of the hf radio system.

#### 1.5 INSTALLATION OF SYSTEM (SITE IMPLEMENTATION)

##### 1.5.1 General Information

Two transmitting antennas at Kano are oriented toward Zanzibar and two toward London. At Zanzibar, two transmitting antennas are oriented toward Kano. An additional steerable antenna at Zanzibar is furnished for communications with the Indian Ocean Ship. It is used on an emergency route between these two sites.

There are four receiving antennas at Kano, two for the Zanzibar circuit and two for the London link. Two rhombic receiving antennas and two log-periodic antennas are provided at Zanzibar. Antenna orientation arrangements are indicated in Figures 1-13 through 1-16.

The receiving and transmitting antenna arrays must have maximum separation to reduce interference within the system. The lack of space for antenna installation on the two ships is a definite disadvantage. Two discone/cage transmitting antennas are used on each of the ship sites. A polarization diversity array will be used for receiving on each ship. The approximate location of these antennas is shown in Figure 1-17. (See MS-121, *Outside Plant*.)

The receiving and transmitting terminal equipment at Kano and Zanzibar are located in separate buildings adjacent to their respective antennas. At these sites, 4 to 6 miles of antenna separation is possible.

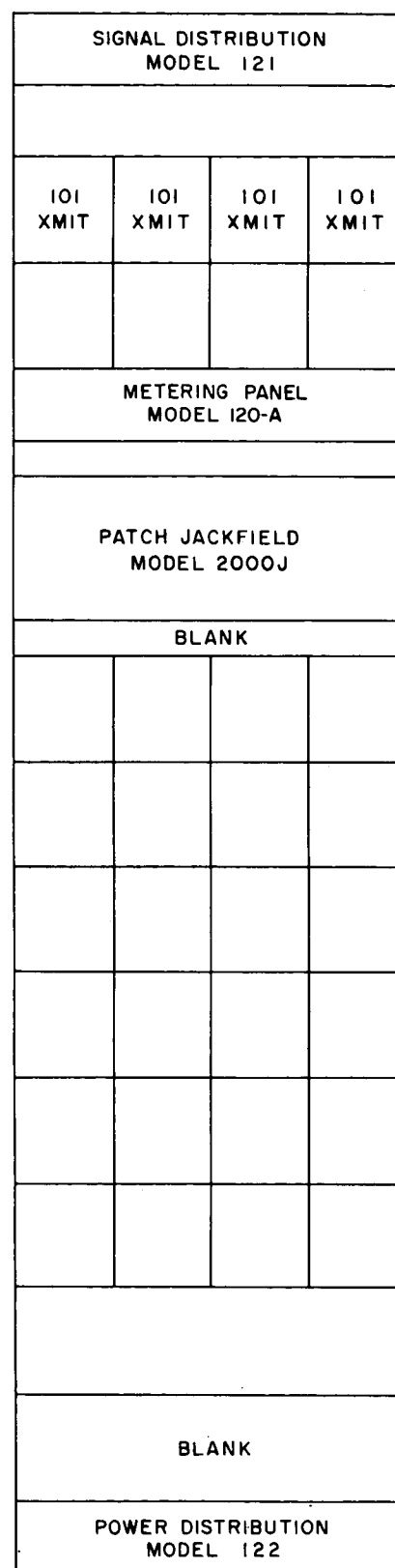


FIGURE 1-12. TYPICAL HF TRANSMITTING LAYOUT, MUX EQUIPMENT

## 1.5.2 Equipment Location

Transmitting equipment is located in the vicinity of the transmitting antennas to keep the transmission line losses to a minimum. The transmitter building houses RF power amplifier, antenna coupling, and switching equipment. Also located in this building are the single sideband mode selector and frequency shift tone multiplexing equipment with the major equipment units cabinet mounted. Each GPT10K-H transmitter cabinet houses the units of a complete single sideband transmitter. Some miscellaneous control, power distribution, and the tone multiplexing equipment units are rack mounted separately.

The diversity receiving units (DDR-6) with mode selector, tone receivers, combiners, and AFC equipment are rack mounted in the receiver building. The control area, near the receiver location, houses the teletypewriter equipment which terminates the Mercury circuits. The dc teletype loops from the receiver and transmitter also terminate here.

Floor plan and face equipment drawings for each site should be consulted for specific equipment location information. The drawings are indexed in Section 5 of this manual for reference purposes.

TABLE I  
HF RADIO EQUIPMENT

<i>Item</i>	<i>Designation</i>	<i>Manufacturer</i>	<i>Kano</i>	<i>Zanzibar</i>	<i>Atlantic Ship</i>	<i>Indian Ocean Ship</i>
Transmitter	GPT10K-H	TMC	4	2	3	2
Receiver	DDR-6	TMC	4	2	3	2
Dummy Load	TER 5000	TMC	2	1	1	1
Filter	HFF	Applied Research Inc.			(As Required)	(As Required)
Antenna Patch *		Andrews	1	1	1	1
Multiplex	102-110	Tele-Signal	14/7	11/3	**	12/6**
Multiplex	101	Tele-Signal	5	7		2
Transmitting Antenna			4***	2*** 1‡	2****	2****
Receiving Antenna			4***	2*** 2‡	2‡‡	2‡‡
Station Guardian	SG-33	M. C. Jones	4	2	3	2

\* Type 24496 at Indian Ocean Ship, 24301 at Zanzibar, 24497 at Kano, 24303 at Atlantic Ship.

\*\* Quadruple Diversity—Receiving Only

\*\*\* Rhombic Antenna (Wind Turbine Co.)

\*\*\*\* Discone/Cage Antenna

‡‡ Horizontal Cage—Conical Monopole Combination

‡ Log Periodic (All Products Co.) LPA 728-A Antenna

TABLE II  
TECHNICAL MATERIAL CORP. GPT10K-H TRANSMITTER

<i>Unit</i>	<i>Designation</i>	<i>Amount</i>
Transmitting Mode Selector	SBE-3	1
Sideband Level Monitor	SLM-Z	1
Frequency Spectrum Analyzer	FSA	1
Master Control Panel	MCP	1
Test Generator	TTG	1
Variable Frequency Oscillator	VOX-3	2
Basic SSB Transmitter	GPT10K-H	1
Misc Wiring-Accessory Assembly		1
Antenna (Coax) Switch Panel	Andrews	1

TABLE III  
TECHNICAL MATERIAL CORP. DIVERSITY RECEIVER, DDR-6

<i>Unit</i>	<i>Designation</i>	<i>Amount</i>
Antenna Multicoupler	HFD-6	1
Antenna Patch Panel	QDP-38	1*
Audio and Teletype Patch Panel	CPP-4C	1*
Single Sideband Receiver	GPR90(RX)	2
Variable Frequency Oscillator	VOX-3	1
Automatic Frequency Control	AFC(MOD)	2
Receiving Mode Selector	MSR-6	2
Accessory Assembly (Cabinet, etc.)		1
Multiplex Wiring and Space		1 (Optional)

\* Requirements will vary at the different sites.

### 1.5.3 Installation

#### 1.5.3.1 General Information

Detailed instructions for installing the HF radio system are covered in the site equipment specifications. These specifications are divided into two sections:

Section A, Installation Instructions

Section B, Summary of Material

Floor plans, face equipment, and site drawings as well as wiring lists for the particular site are listed in the above sections. Section 5 of this manual also lists site drawings.

The HF radio equipment is ordered on a terminal basis, but for convenience in handling and shipping, this equipment is crated and

shipped as units. The DDR-6 receiving terminal and the GPT10K-H transmitting terminal are supplied by the Technical Material Corporation while the Tele-Signal Corporation supplies the tone multiplexing units. The GPT10K-H transmitter, for example, is packed and shipped in approximately 16 wooden boxes. Unpacking and assembly information is detailed in the various manufacturers' equipment manuals.

#### 1.5.3.2 Rack and Cable Installation

Typical installation procedures follow a pattern as shown below:

- a. Rack stringers positioned (floor bolts installed prior, as per floor plan).
- b. Equipment racks and cabinets tied to rack stringers and floor bolts.

TABLE IV

#### TELE-SIGNAL CORP. FREQUENCY SHIFT TONE EQUIPMENT (MUX)

<i>Unit</i>	<i>Designation</i>	<i>Amount*</i>
Signal Distribution Panel	121	1
Tone Transmitter	101	1 to 8
Patch Field	2000J	1
Tone Receiver	102	1 to 8
Dual Diversity Comparator	110	1 to 4
Twinning Panel	110A	1 to 6**
Transistor Switch	109P/B	1 to 4
Power Distribution Panel	122	1
Rack, Cabinet, Blanks (Set)		1
Meter Panel	120	2
Power Supply	126	2

\* Amount per terminal. Number of units will vary at each site. See Table I.

\*\* Use at ship sites for quadruple diversity.

- c. Cable ladders (or racks) attached to the top of the equipment racks.
- d. Coax, switches, filters or balun coils, and other rf apparatus attached to the cable ladders and racks.
- e. Junction panels and terminal boards mounted.
- f. Cables placed in overhead racks or ladders.
- g. Intrabay cabling (wiring harnesses) installed and cut-down.
- h. Primary power cables installed and cut-down on terminal boards.

The prefabricated wiring harnesses, equipment racks and structural framework predetermine the requirements of close tolerances during the installation phase.

It must be noted that no power should be applied to the power circuits, cables, or rack wiring at this point in the installation.

### 1.5.3.3 Unit Installation

The receiving and transmitting equipment is

installed independently in the respective buildings. The final installation and testing of the common equipment in the control area is dependent on the prior installation of the equipment in the receiving and transmitting area.

Unit location deviation must be kept to a minimum due to the use of precut wiring harnesses and coaxial cables. The manufacturer's equipment manual, shipped with each unit, outlines specific installation instructions for the unit. The system installation instructions and interconnecting information is outlined in the A section of the equipment specification for each site.

Preliminary installation tests are made after the units are installed and the wiring harnesses are cut-down on terminal boards. These tests determine the correctness of installation and cross connection. Before primary power is applied to the equipment, wiring checks and resistance measurements may be required. Where these tests apply, they are detailed in the manufacturer's equipment manual and should be followed.

TABLE V  
FARINON ELECTRIC CO. UHF RADIO (ZANZIBAR ONLY)

<i>Unit</i>	<i>Designation</i>	<i>Amount</i>
Transmitter	PT 450*	8
Receiver	PT 450*	8
Diplexer	SD-10270-M2	4
Transfer Panel	SD-10143 (TR)	4
Transfer Panel	SD-10144 (REC)	4
Telephone Multiplex**	45CX	4
Tone T&R Equipment***	TR101 REC102	As Required

\* XMTR and RCVR are units of a complete terminal unit.

\*\* Manufactured by Lenkurt Electric Co.

\*\*\* Manufactured by Tele-Signal Corp.

TABLE VI  
EQUIPMENT MANUALS

<i>Manufacturer</i>	<i>Title</i>
TMC	ME-704, Technical Manual for Transmitting Set, Radio, Model GPT-10KH (AN/FRT-39, 39A) Volume I (IPA and PA) Volume II (Exciter and Test Equipment) Volume III (Parts List)
TMC	ME-706, Technical Manual for Receiving Set, Radio, Model DDR-6
T/S*	F/S Tone Transmitter, Model 101, Instruction Book
T/S	F/S Tone Receiver, Model 102, Instruction Book
T/S	Dual Diversity Comparator, Model 110, Instruction Book
T/S	Twinning Panel, Model 110A, Instruction Book
T/S	Transistor Switch, Model 109PB, Instruction Book
Farinon**	ME-703, PT450 Technical Information Manual
Lenkurt**	ME-708, Instruction Manual, Lenkurt, Type 45CX1
All Products Co.	ME-719, Log Periodic Antenna LPA 728/A Instruction Book
Allied Research	ME-702, Instruction Manual—Filters for Project Mercury Ground-to-Ground Communications System.

\* For Mercury application, all T/S manuals are consolidated in ME-701.

\*\* Zanzibar only

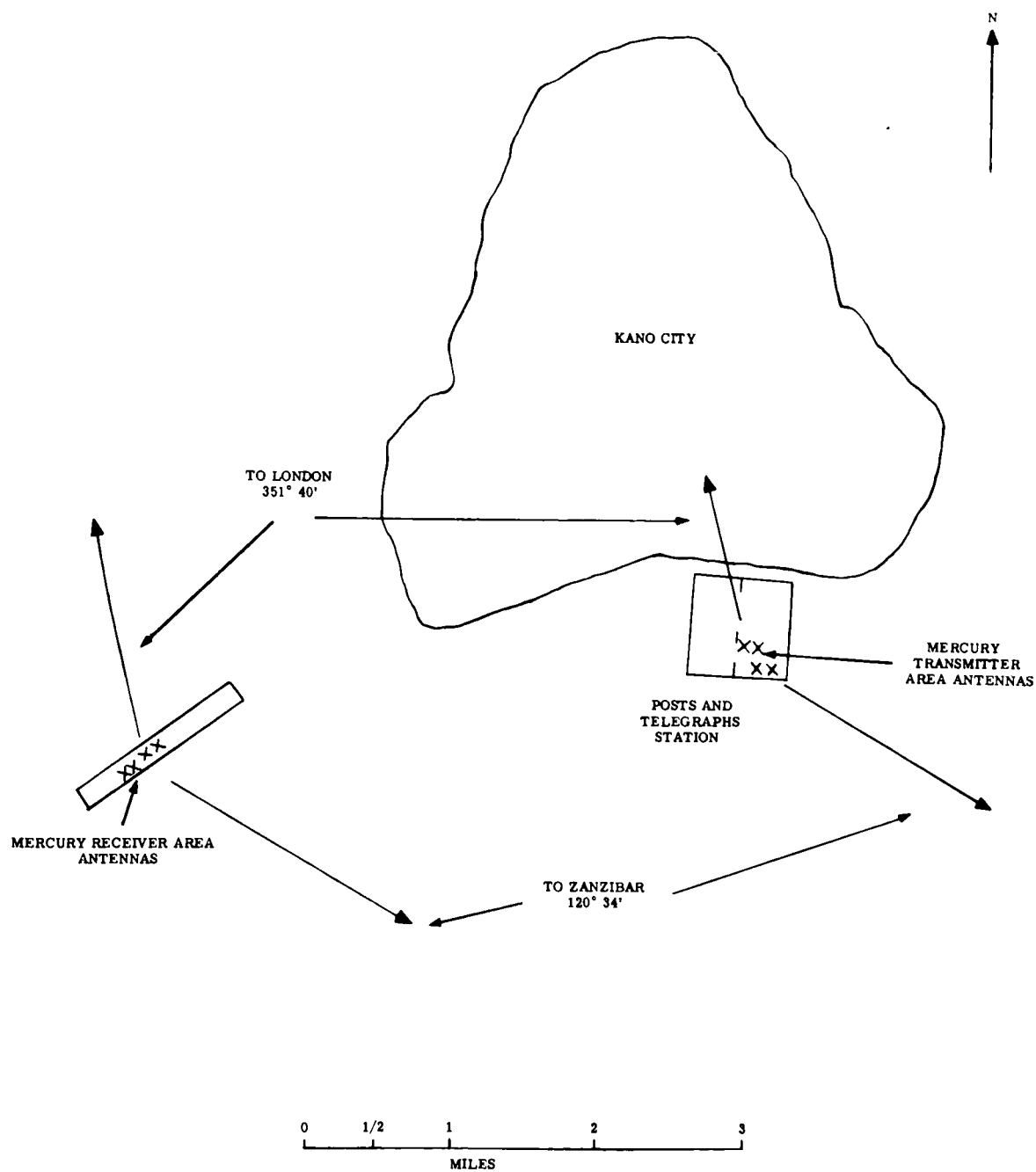


FIGURE 1-13. KANO ANTENNA ORIENTATION

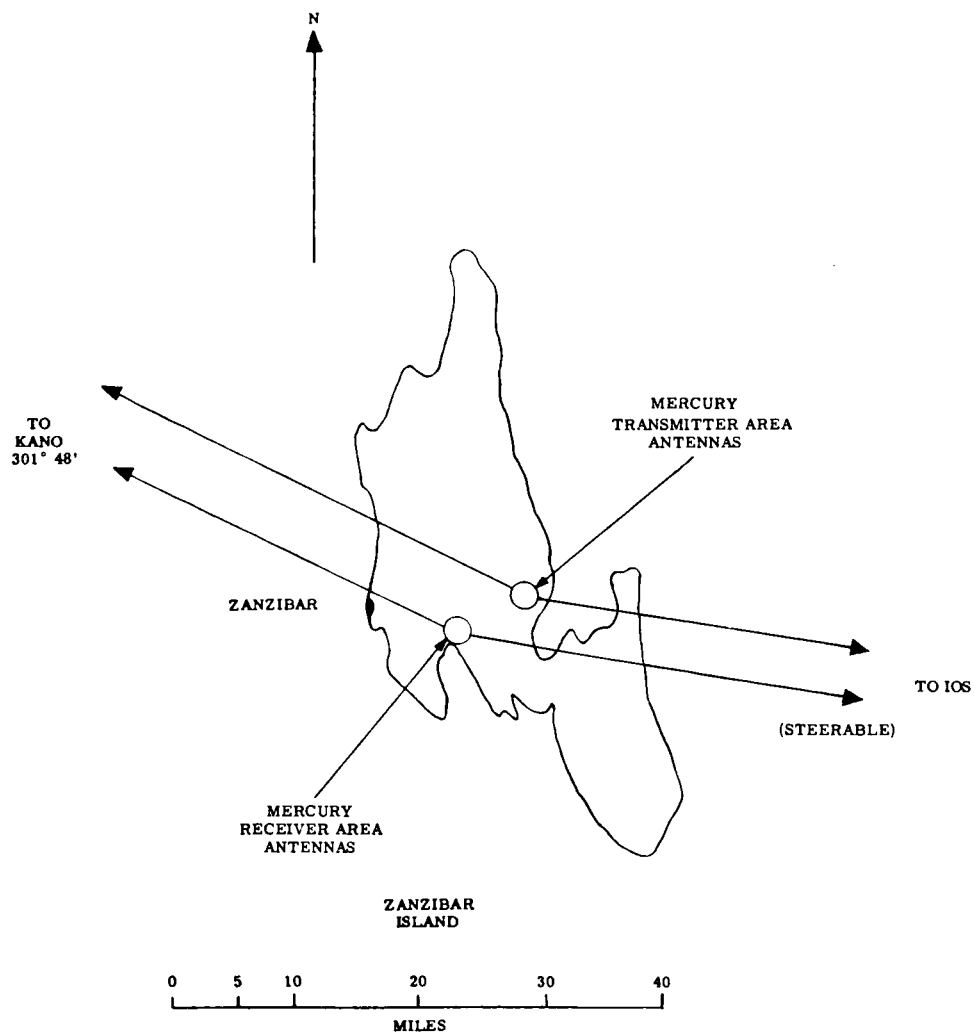


FIGURE 1-14. ZANZIBAR ANTENNA ORIENTATION

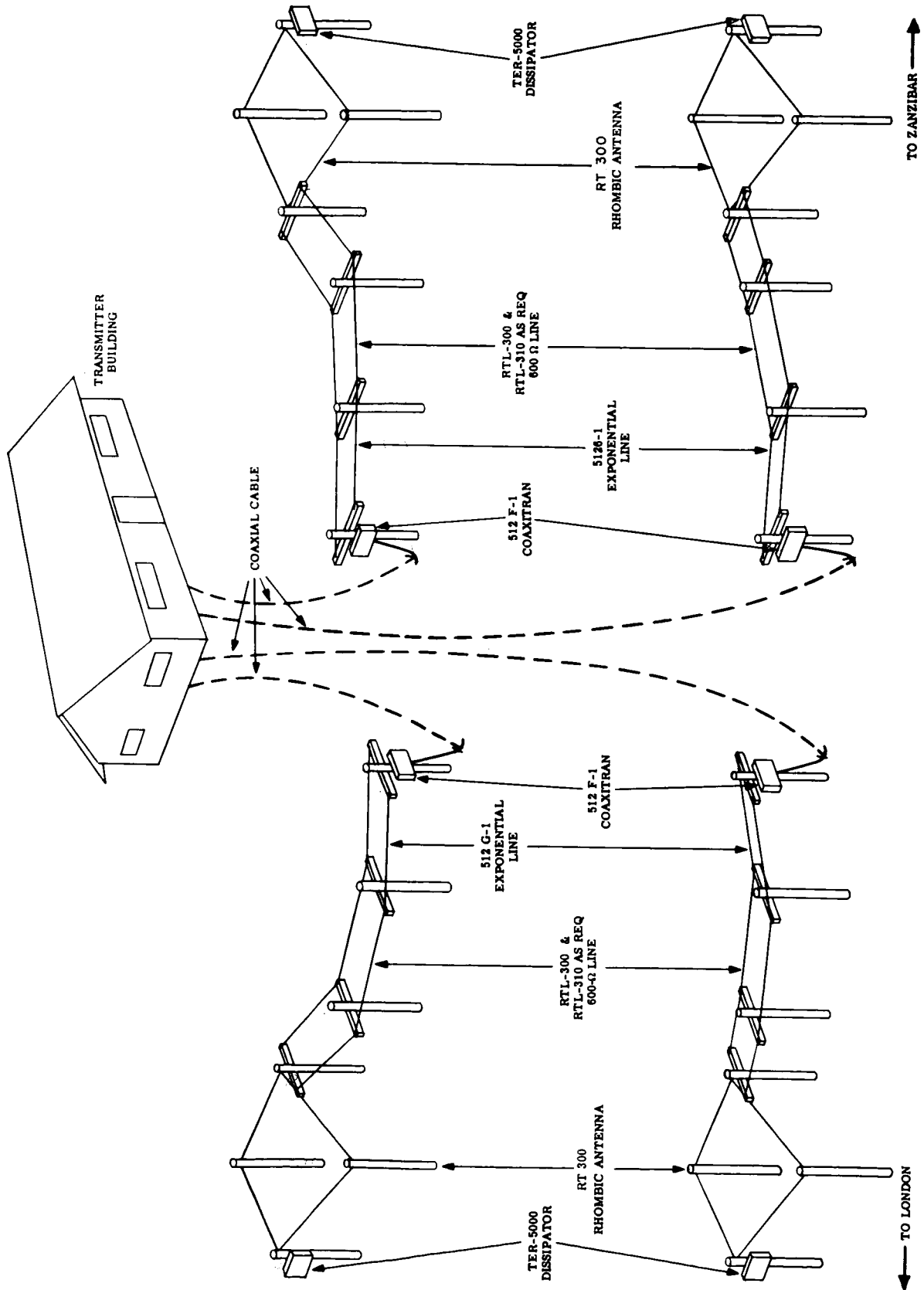


FIGURE 1-15. KANO TRANSMITTER ANTENNA

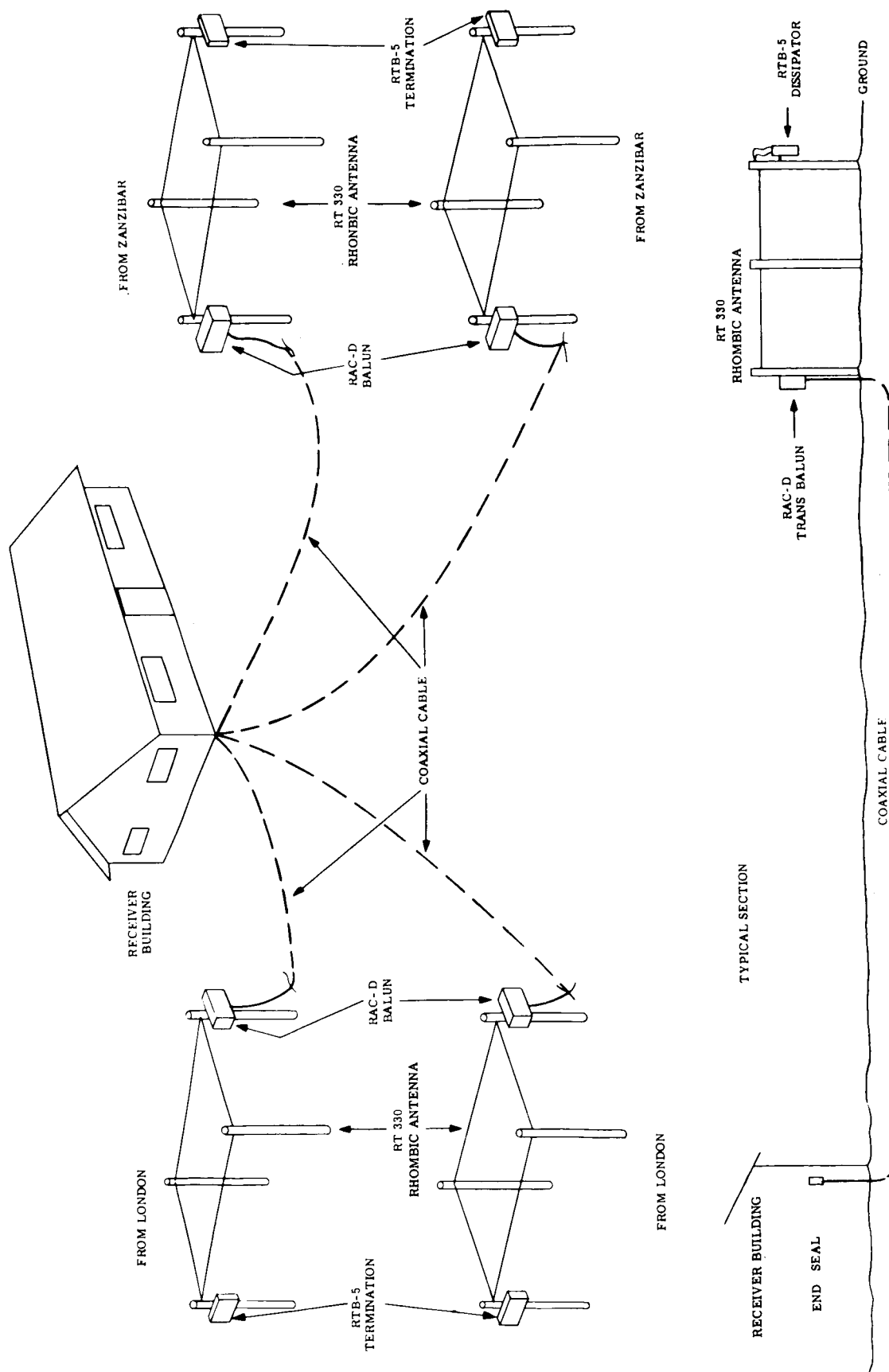


FIGURE 1-16. KANO RECEIVER ANTENNA

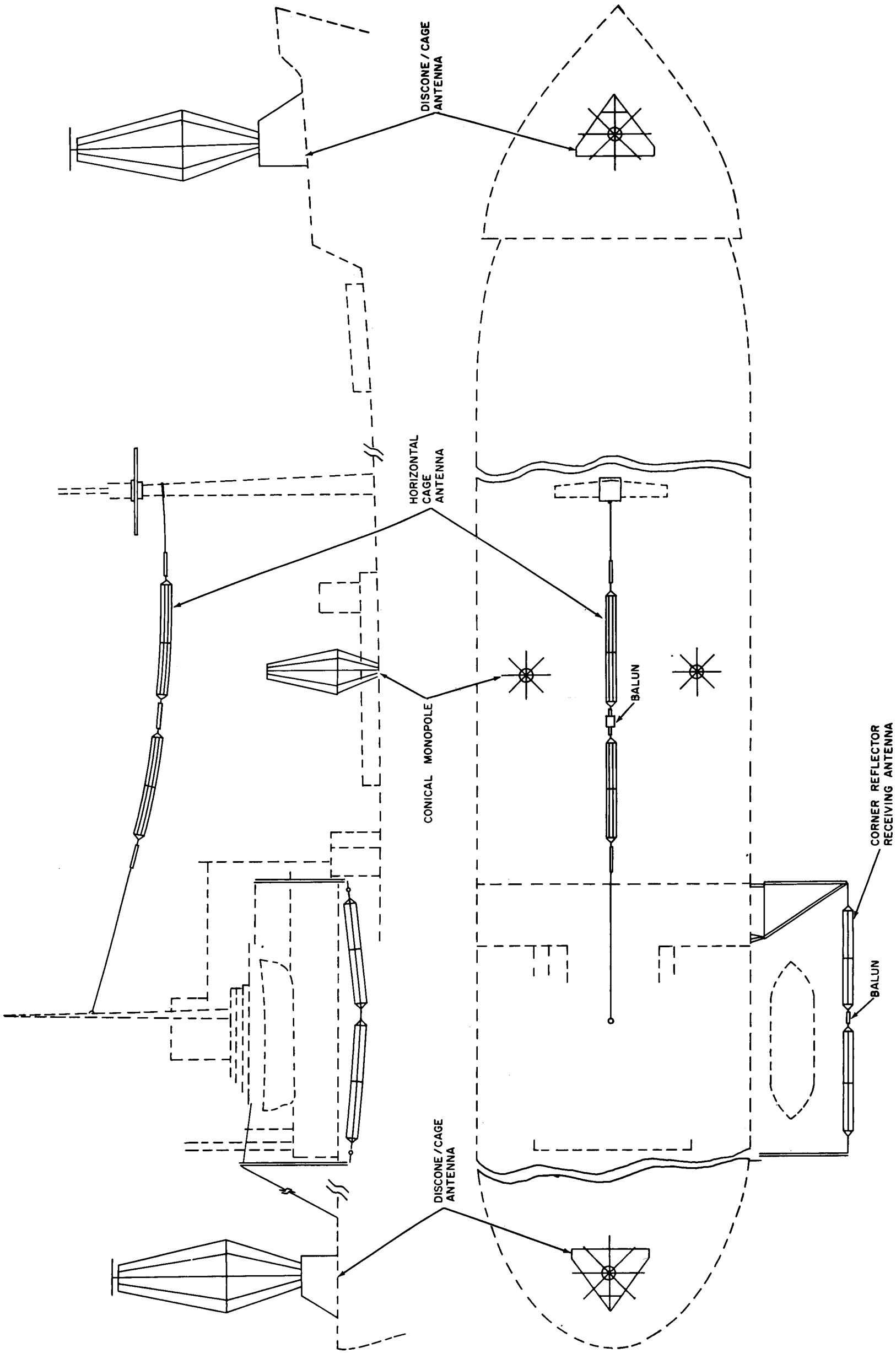


FIGURE 1-17. SHIPBOARD ANTENNA ORIENTATION

## SECTION 2. THEORY OF OPERATION

### 2.1 EQUIPMENT THEORY

#### 2.1.1 Antenna System Theory

The rhombic transmitting antenna is designed to direct the maximum energy in the desired direction and suppress radiation in other directions. On shipboard, an omnidirectional vertical antenna is more applicable due to space limitations. As the optimum condition for a receiving antenna is not necessarily maximum received power but maximum signal-to-noise ratio, a minor lobe in the receiving antenna pattern may introduce a large amount of noise if it is directed toward a noise source. This could result in a low signal-to-noise ratio although the main lobe was directed toward the signal source. Surrounding objects, as experienced on shipboard, will effect the antenna pattern. Tests were required to determine the patterns of the shipboard antennas after installation is completed.

In the Mercury HF radio complex, separate antennas are used for transmitting and receiving so that full duplex circuits can be derived. The rhombic array was selected for use at the Kano and Zanzibar sites. This antenna system requires large amounts of space for installation, but the space is available at these sites. The receiving antennas (two per link) are arranged for space diversity reception. The transmitting antennas are cut for a mean frequency in the 7- to 28-mc spectrum. The rhombic antenna is a unidirectional antenna when properly terminated and is superior to the long wire and V antennas. The rhombic contributes increased gain, broadband response, and a radiation pattern which is a function of leg length, tilt angle, elevation above ground, and the terminating resistance impedance match. The antenna arrangement is shown in Figures 1-4, 1-15, and 1-16.

The LPA 728-A log-periodic antenna is a unidirectional, broadband antenna designed to operate from 7 mc to 28 mc. The use of off-set

straight elements as a logarithmical periodic antenna structure is an innovation which gives mechanical and electrical characteristics. The characteristic impedance of this antenna is approximately 135 ohms. This impedance is transformed to 50 ohms by a stepped exponential line, which is approximately 40 feet long. An electrical rotator and control panel permit continuous rotation at a speed of 1/2 rpm. This antenna is shown in Figure 2-1.

Shipboard antennas are restricted to vertical or short horizontal arrays due to space limitations. The discone/cage antenna is used for transmitting. This antenna has an omnidirectional radiation pattern in free space, but the pattern will be somewhat distorted by the shipboard installation. It is a derivation from a ground plane antenna and has a broadband response. Two of these antennas are provided on the Atlantic Ship and two on the Indian Ocean Ship. The antenna arrangements are shown in Figure 1-5. The receiving antennas on the ships are arranged for polarization diversity reception. A conical monopole (vertical) and a horizontal cage antenna are used. The horizontal antenna arrangement is shown in Figure 1-6 and the vertical antenna in Figure 1-7. See MS-121, *Outside Plant*, for the details on RF patch panels, pressurized transmission lines, and the various antenna systems.

#### 2.1.2 Transmitting System Theory

The transmitting system is shown in the block diagram (Figure 2-2) and in the simplified schematic diagram (Figure 2-3).

The shipboard filters are of the plug-in type so that the proper filter can be inserted depending on the operating frequency. The exciter filter, HFF-D-5, and the PA filter, HFF-3, are mated filters. The exciter filter is mounted inside the transmitter cabinet. The PA filter is mounted external of the transmitter. These filters are cov-

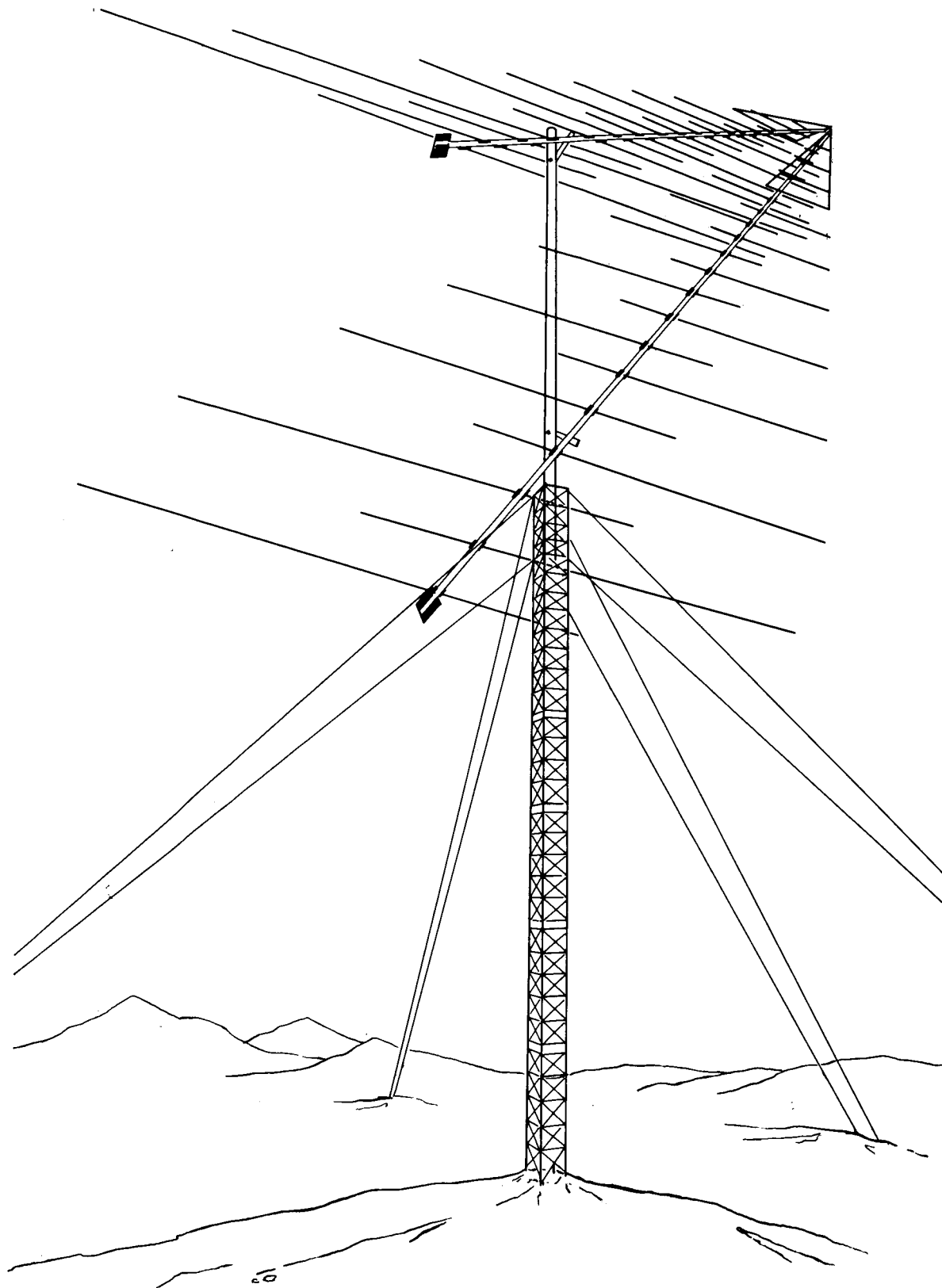
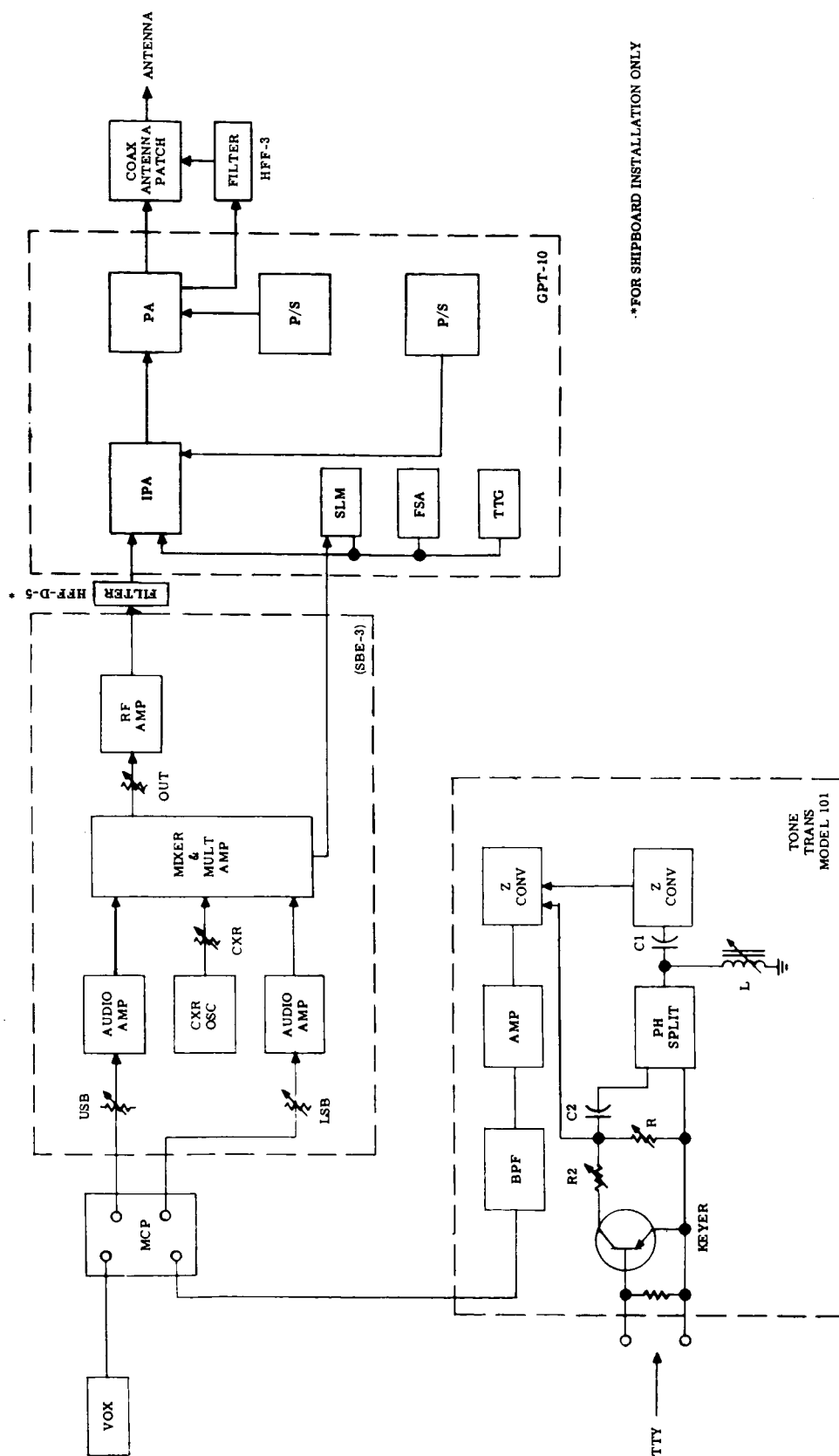


FIGURE 2-1. LOG-PERIODIC ANTENNA (LPA 728-A)



\*FOR SHIPBOARD INSTALLATION ONLY

FIGURE 2-2. HF TRANSMITTING SYSTEM

ered in detail in MS-121, *Outside Plant*, and also in ME-702, *HF Filters*.

The teletype equipment, including a 255A or 33RY relay, supplies neutral (make-break) signals to the tone multiplexing equipment over a loop operating at 62.5 ma. (See MS-108, *Teletypewriter*.)

The F/S tone transmitter (Tele-Signal Corp., model 101) provides the transmitting terminal with frequency shifted signals in the audio spectrum. As shown in Figure 2-3, series tuned L/C circuit L101-C101 is driven by two stages of impedance step-down conversion, V1-V2. The voltage across L101 drives phase splitter V3 which feeds R/C circuit R106-C103. Varying the effective resistance in this R/C circuit, with keying transistor V6 circuit, permits change of phase angle from 0 to 180 degrees. The feedback, from the junction of R106/C103 to the impedance converter causes regeneration, resulting in oscillation at the channel center frequency. If the effective resistance of R106 is increased, the oscillation frequency will be lowered (space frequency). The application of sufficient current to keying transistor V6 will effectively parallel R104 and R106, due to base saturation of the transistor. The lower resistance will cause the circuit to oscillate at a higher frequency (mark condition).

The center frequency (channel frequency) is governed by the L, C, and R components contained in the plug-in network associated with the tone transmitter. The channels are spaced 170 cps apart and the standard shift is  $\pm 42.5$  cps. The audio tone is amplified by V5 and passes through a bandpass filter to terminal block J2. The unit has a self-contained bridge-type rectifier for necessary voltage supplies.

Audio tone signals pass from the tone transmitter to the transmitting mode selector (Technical Material Corp., model SBE-3). Functionally, the SBE-3 amplifies the tone and raises it in frequency. The SBE-3 is a filter-type sideband generator, intended for use as an exciter for the GPT10K-H single sideband transmitter.

The audio tones mentioned above are amplified in V102 or V103. These signals are also fed through meter amplifiers and a rectifier circuit

to a peak reading meter circuit. CR101 and CR102 form a bridge-type diode modulator. A highly stable 17-kc signal is also introduced into this modulator circuit. The 17-kc carrier is balanced out in the modulator and 17 kc plus the audio and 17 kc minus the audio passes on to filters Z101 and Z102. Z101 passes only 13.7 kc to 16.65 kc and Z102 passes only 17.35 kc to 20.65 kc. Z106 is a 17-kc notch filter which further reduces the 17-kc signal to an insignificant level. Two stages of amplification follow (V108A and V108B). Any level of carrier can be inserted for transmission by the adjustment of R106. The signal is mixed in balanced modulator CR103 with the output of 28-kc oscillator. This signal is again amplified and mixed in midfrequency balanced modulator V113A and V113B, with a signal from the 2- to 4-mc MF oscillator. The signal, now in the 2- to 4-mc range, is amplified in V114, the MF amplifier. This signal is further increased in frequency when mixed with signals from the HF oscillator (8 to 34 mc), in Z107, the HF diode modulator. The output of Z107 is coupled to V118, the first RF amplifier. The signal is in the 4- to 32-mc range at this point. The following three stages (V118, V119, and V120) increase this HF signal to the rated 3-watt peak envelope power at the output of the exciter.

The 3 watts of RF power drive the single sideband transmitter (TMC GPT10K-H). It is a general purpose transmitter operating as a linear amplifier over the 4- to 28-mc range. The 3-watt input is increased to 10 kw (PEP) at the transmitter output. This is accomplished in three intermediate amplifier stages (V201, V202, and V203) and a power amplifier stage. Power amplifier V900 is a ceramic, 4CX5000-A tube.

A sideband level monitor (SLM), frequency spectrum analyzer (FSA), and test generator (TTG) are also provided on the auxiliary frame of the transmitter unit. The SLM provides metering circuits which indicate the levels in the LSB/USB filters of the SBE-2 unit. The FSA permits analysis and identification of RF signals at various points. A cathode-ray tube is used and the amplitude and position of the pip is indicative of the signal level and frequency. The

TTG furnishes two audio tones (935 and 2805 cps) for distortion measurement of the transmitter output signals.

Theory of operation of each transmitting unit is covered in ME-704, GPT10K-H equipment manual. Tone transmitter operation and theory is covered in detail in ME-701, *Diversity Telegraph System*.

### 2.1.3 Receiving System Theory

The HF diversity receiving system is shown in the block diagram (Figure 2-4) and in the simplified schematic diagram (Figure 2-5).

The DDR-6 is a diversity receiving system (TMC) providing coverage from 0.5 to 31.0 mc. The DDR-6 includes two GPR-90RX communications receivers and two MSR-6 receiving mode selectors with injection voltages supplied by a variable frequency oscillator, VOX-3. Antenna, audio, and teletype patch jacks and an HFD-6 antenna multicoupler (land sites only), are also located in the DDR-6 rack. An HFD-6/4 filter is used for installation at the shipboard sites, between the antenna and the receiver.

The received signal is passed from the rhombic antennas at Kano and Zanzibar to the antenna patch jacks in the receiver area. The signal is then patched to the antenna multicoupler HFD-6 (TMC). The multicoupler is a 70-ohm, broadband device which can be used to isolate as many as four receivers connected to the same antenna. There are active and passive type couplers. The HFD-6 is a passive coupler and will present maximum margin to overload and intermodulation in the vicinity of high intensity rf signals. It consists of a broadband transformer with a 70-ohm input and four secondary windings of 70 ohms each. A receiver connected to each of the four 70-ohm outputs will result in an approximate four to one power loss. Terminations are not required on the spare outputs, and the losses will be correspondingly reduced as the number of receivers connected are reduced. The signals pass from the coupler to the GPR-90RX. This receiver is relay rack mounted and contains 17 tubes and 10 (crystal)

positions for fixed frequency operation. The spectrum is covered by band switching over six bands.

The shipboard receive filters and patch jacks are shown in the insert of Figure 2-4. The receiver filter cabinet is shown on drawing DP-11218. The antenna, filter, and receiver connections are brought out to coax jacks so that any combination of antennas, filters, and receivers can be readily patched together. These filters are covered in detail in MS-121, *Outside Plant*, and ME-702, *HF Filters*.

The receiver circuits include two RF amplifier stages, V1 and V2. A 100-kc calibration signal is introduced at the receiver input. This signal is generated in 100-kc oscillator circuit V16. First converter V3 receives the RF signal on its control grid, and the HF oscillator signal is introduced in the cathode circuit. The HFO signal can be generated internally in 10-channel crystal controlled oscillator circuit V12 and V17, or the signal can be introduced from an external variable oscillator (VOX). This is introduced at J5. The output of the first converter passes through T3, a 3.955-mc IF transformer and is introduced into second converter and oscillator circuit V4. The signal is mixed with a 3.5-mc crystal controlled signal and the resultant 455-kc IF signal is passed through T5, a 455-kc crystal filter and three stages of IF amplification (V6, V7, and V8). IF output jack J1A is coupled to the plate of third IF amplifier V8. The 455-kc IF signal then is passed to the MSR-4 mode selector.

The Technical Material Corporation MSR-6 single sideband converter (receiving mode selector) is used for SSB tuning and selection of the proper sideband. The combination of a filter circuit and frequency bandspread tuning provides sharp discrimination between a desired signal and undesired adjacent interference. The carrier is reinserted in the MSR-6 and its output is audio frequency tones.

The 455-kc IF signal from the receiver enters the MSR-6 at J1. One stage of if. amplification is provided V2 before first mixer circuit V3. First oscillator V7 is crystal controlled. Two crystals are used to select either sideband. (See

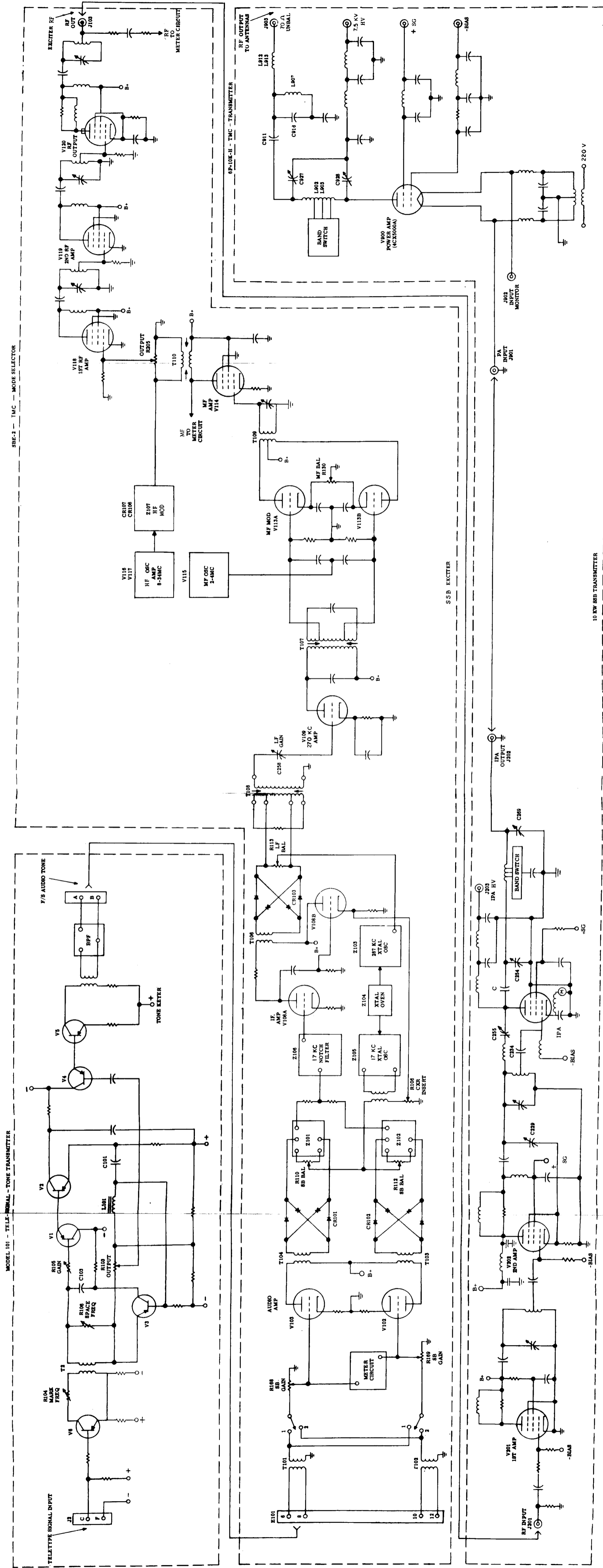


FIGURE 2-3. HF TRANSMITTING SYSTEM, SIMPLIFIED SCHEMATIC DIAGRAM

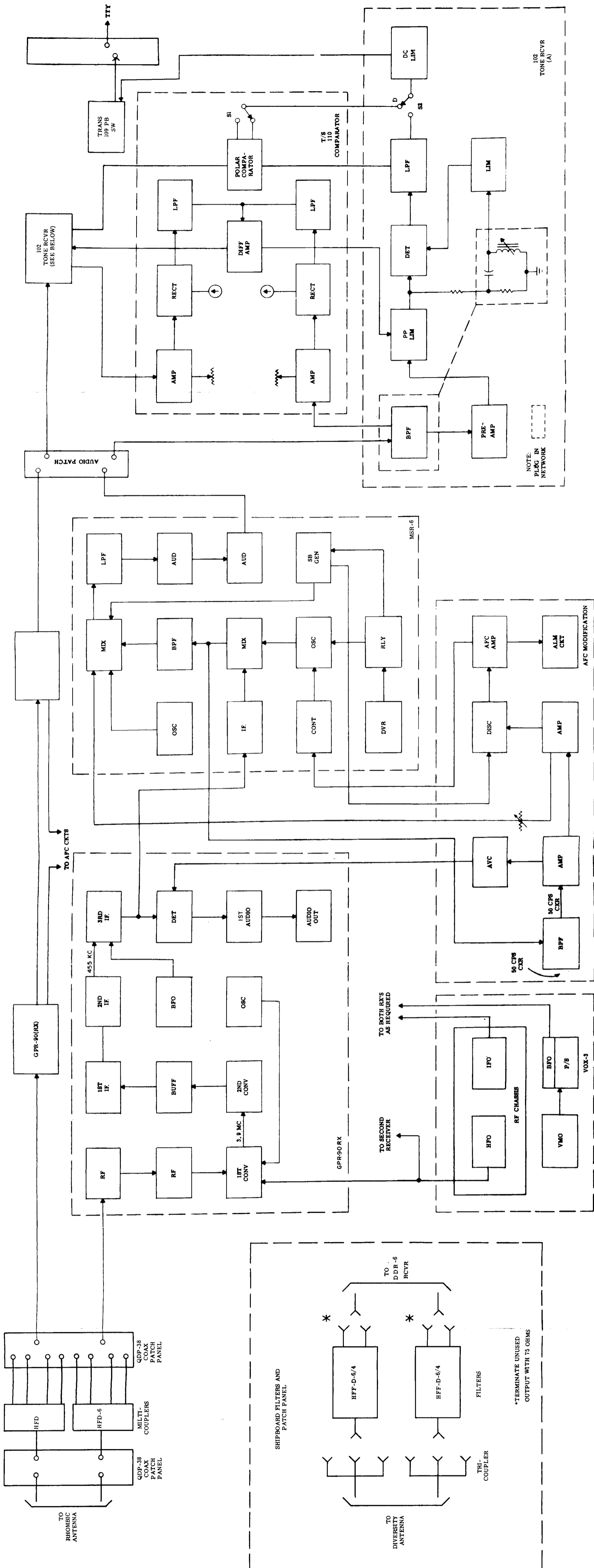


FIGURE 2-4. HF DIVERSITY RECEIVING SYSTEM

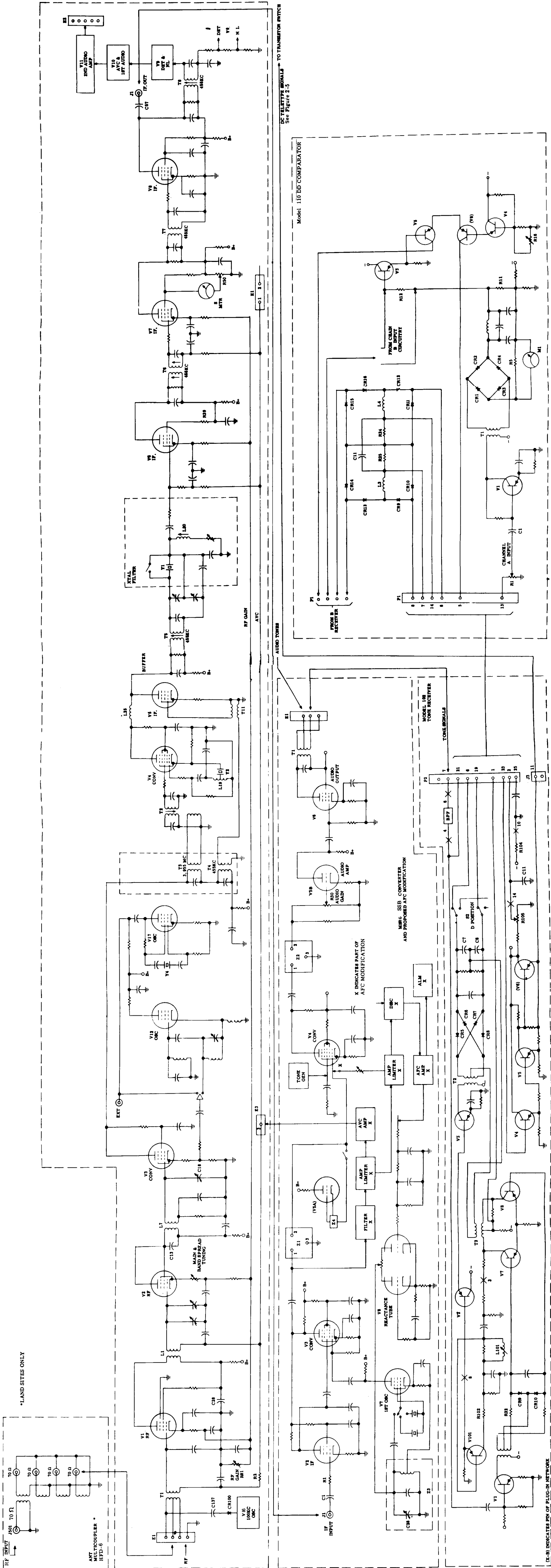


FIGURE 2-5. HF DIVERSITY RECEIVING SYSTEM, SIMPLIFIED SCHEMATIC DIAGRAM

paragraphs regarding the AFC modification.) The output of the mixer is a 17-kc signal plus the sideband that is chosen, and it is passed through bandpass filter Z1. This signal is again mixed in second mixer V4, and at this point a 17-kc signal is introduced from second oscillator circuit V5A. In second mixer circuit V4, the 17-kc carrier is removed and the sideband information is passed through Z2 which is a low pass filter that cuts off all frequencies above 3500 cps. The audio (sideband) information is then amplified in two stages of audio amplification, V5B and V6. The audio output of the MSR-6 appears on the E1 terminal strip of the unit. The audio signal passes to the tone receiving equipment (Tele-Signal Corp.), which is described later in this section.

The VOX is a direct reading precision variable frequency oscillator. It replaces the oscillators of the diversity receivers and supplies HF and IF signals as required for stable operation on Mercury circuits.

The automatic frequency control (AFC) modification equipment is added to the Technical Material Corporation's DDR-6 receiving system to correct frequency drift and to improve the automatic volume control (AVC) action of the GPR-90 RXD receiver and the MSR-6 mode selector.

In the MSR-6, the 455-kc IF signal from the receiver passes through stage of amplification V2 to first mixer V3. The 17-kc output is passed to Z1, and a portion of this signal is picked off and passed to the BP filter of the AFC modification unit. The bandpass of this filter is extremely narrow (30 cps) and passes only the transmitted carrier. With this narrow bandwidth, optimum signal-to-noise conditions are derived and the SSB transmitter can be operated with a carrier level 10 to 15 db below the sideband level. The signal is amplified and limited and an AVC voltage is derived which is further amplified and used to control the circuits of the receiver. A second amplifier/limiter circuit provides a 17-kc reinjection voltage to second mixer V4 to drive the discriminator of the AFC circuit. The discriminator (phase detector) provides a correction voltage indicative of transmitter carrier drift. The

discriminator correction voltage is amplified and the level adjusted to drive the reactance control tube in the MSR-6. The alarm circuit automatically indicates the loss of received carrier and an excessive drift condition.

The tone receiver (Tele-Signal Corp., model 102) and the dual diversity comparator units (model 110) make up the receiving terminal which demodulates the audio tones and produces the dc teletype signals. Two tone receivers and the comparator unit are used on each diversity channel. The number of units double in the case of quadruple diversity (polarization and frequency diversity) as used on the Atlantic and Indian Ocean Ship sites. A model 109 P/B transistor switch will be used for each diversity channel; and in the case of quadruple diversity, four receivers, two parallel comparator units, a twinning circuit, and a transistor switch will be used. The switch and the comparator units are primarily dc coupling devices between the tone receivers and the teletypewriter equipment.

Audio tones are introduced at terminal 7 of P2 on the receiver unit and feed through the BP filter section of plug-in frequency determining network P101-J1 to preamplifier stage V1. The signal is transformer coupled T1 to push-pull limiter circuit V7-V8, with the output fed into the polar detector consisting of CR5 through CR8. The output of the limiter also feeds a series tuned circuit in the plug-in network. The square waves fed into this tuned circuit are passed through transistor V101 which is an isolation stage and the combination of V2 and V3, the amplifier-limiter circuit. This limiter output is also transformer coupled to the polar detector. The polar detector is essentially a phase discriminator which compares the relative phase of these two square wave signals. The tuned circuit produces a 90-degree phase shift at the center frequency, and the space and mark frequencies create phase shifts of more or less than 90 degrees. Polar currents flow through R11 and R12 in the output of the detector with the circuit acting as a polar fm discriminator. Switch S2 is a sense inverting switch. The output of this discriminator is fed through LP filter L1-C9, impedance converter V4, and a dc limiter or trigger circuit consist-

ing of V5 and V6. The 36 point jack, P2, in the rear of the receiver, is used for connection to the comparator unit, via the wiring harness. The signals from the A and B receivers are introduced into the comparator units at P1 (pins 13 and 33). The signal path from receiver A is through attenuator R1, amplifier V1, and rectifier CR1-CR4, while the path from the B receiver is through R7, V2, and CR5-CR8. These signals are individually metered at the output of the two bridge rectifiers. The output of the two rectifiers (dc of opposite polarities) are added. If signal A is larger than signal B, the output voltage will be positive. If signal A is smaller than signal B, the output voltage will be negative. The magnitude and polarity of this voltage is the diversity information required and is used to bias push-pull limiters V7-V8 of the tone receivers. The bias circuits to the A and B receiver are through V3-V4 and V5-V6, respectively. The limiter associated with the receiver having the stronger signal is biased for increased amplification, while the limiter associated with the receiver having the weaker signal is biased for reduced amplification. With the sense switch of the two receivers in the D (diversity) position, the circuit to the receivers' dc limiter or trigger stage is open and the discriminator outputs are applied to diode comparator CR9-CR16. The comparator output signal passes through LP filter L3 and L4-C11 and C12, sense switch S1, and back through the dc limiter or trigger circuit of the A tone receiver.

The output of receiver A (J3-pin 11) connects to the teletype circuit through a transistor switch. In the Mercury application, the Tele-Signal Corporation (model 109 P/B) switch is connected directly to the rear of the A 102 receiver unit. The transistor switch is primarily an output coupling device intended to drive such circuits as teletypewriter equipment may require. The dc from the trigger stage of the A tone receiver drives isolation stage V1 in the switch circuit. When V1 is saturated, it

provides a short circuit from emitter to base and cuts off V2 in the three transistor switch chains (V2, V3, and V4). When V1 is cut off, the base of V2 returns, through R2, to line battery and V2 is saturated along with V3 and V4. The drop across the three switch transistors is now essentially zero. These three transistors can be viewed as the equivalent of an off-on contact. The transistor switch provides signal inversion and it is necessary to place the sense switch of the partner F/S tone receiver in the negative position. When this is done, a mark frequency on the tone line will produce a mark (current on) condition in the teletype loop.

In the Mercury application, the tone receiving equipment arrangements will vary at the different sites. At Kano and Zanzibar, there is space diversity and two receivers; a comparator and a 109 P/B switch are used for each circuit (Figure 2-6). At the Atlantic and Indian Ocean Ship sites, polarization diversity and frequency diversity are used. At these sites, the tone receiving equipment consists of four tone receivers, two comparators, a 110A quadruple diversity adapter, and a 110A twinning control panel as shown in Figure 2-7. This arrangement allows for operation of two dual diversity channels (one quadruple diversity channel) on a single teletypewriter circuit.

## 2.2 OPERATION THEORY (SITES)

### 2.2.1 General Information

At times other than during orbital flight, the HF radio system will be used for administrative traffic. During an orbital flight, the site will receive teletype messages from the Goddard computer to assist in acquiring the capsule. The message will contain azimuth, elevation, and time coordinates. After each pass over any site, a summary of the telemetered data is made up and transmitted to the Goddard Space Flight Center via the teletype circuits. Refer to MG-102, Section 15, Teletype Format A.

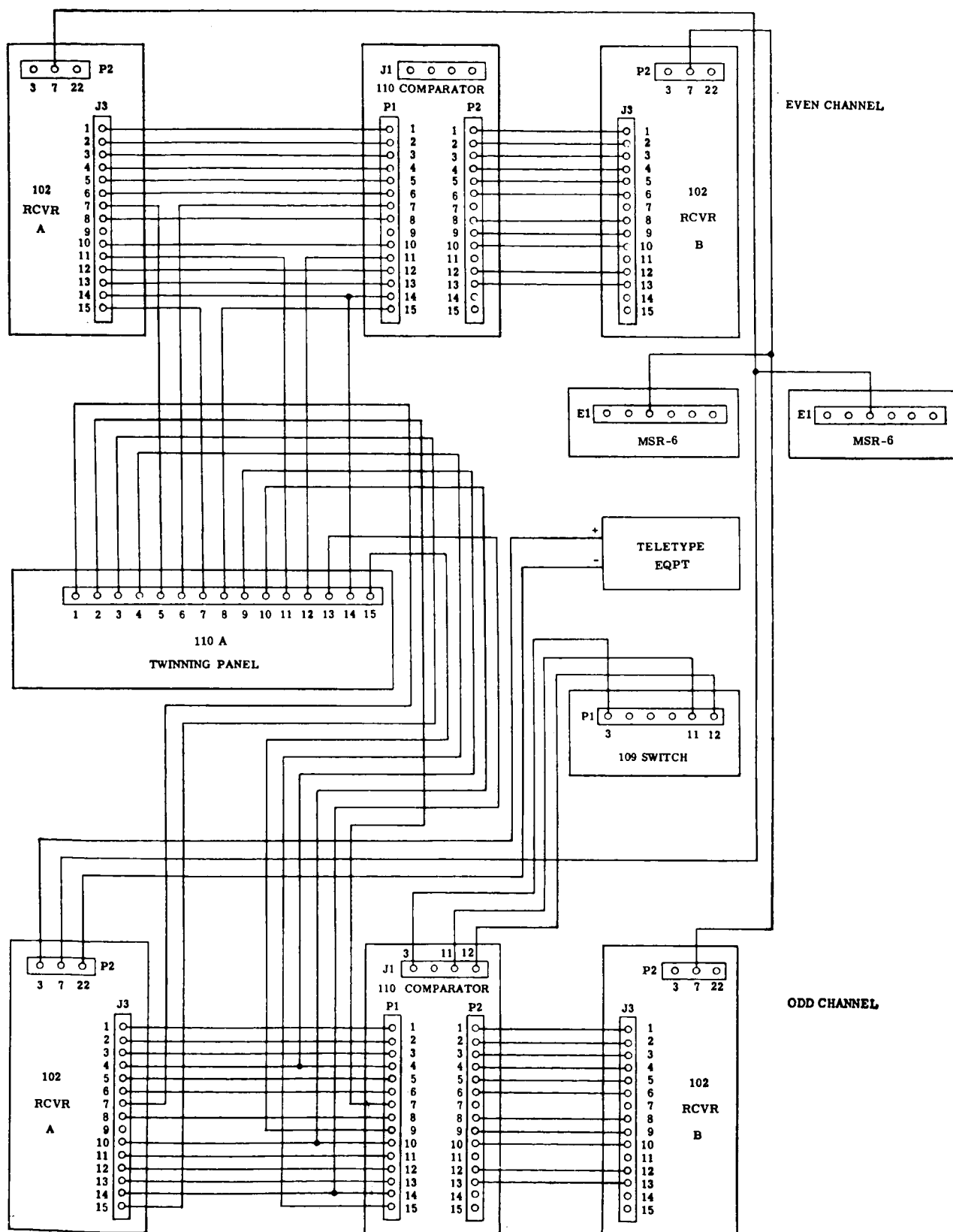


FIGURE 2-6. TONE RECEIVING EQUIPMENT CONNECTIONS, DUAL DIVERSITY

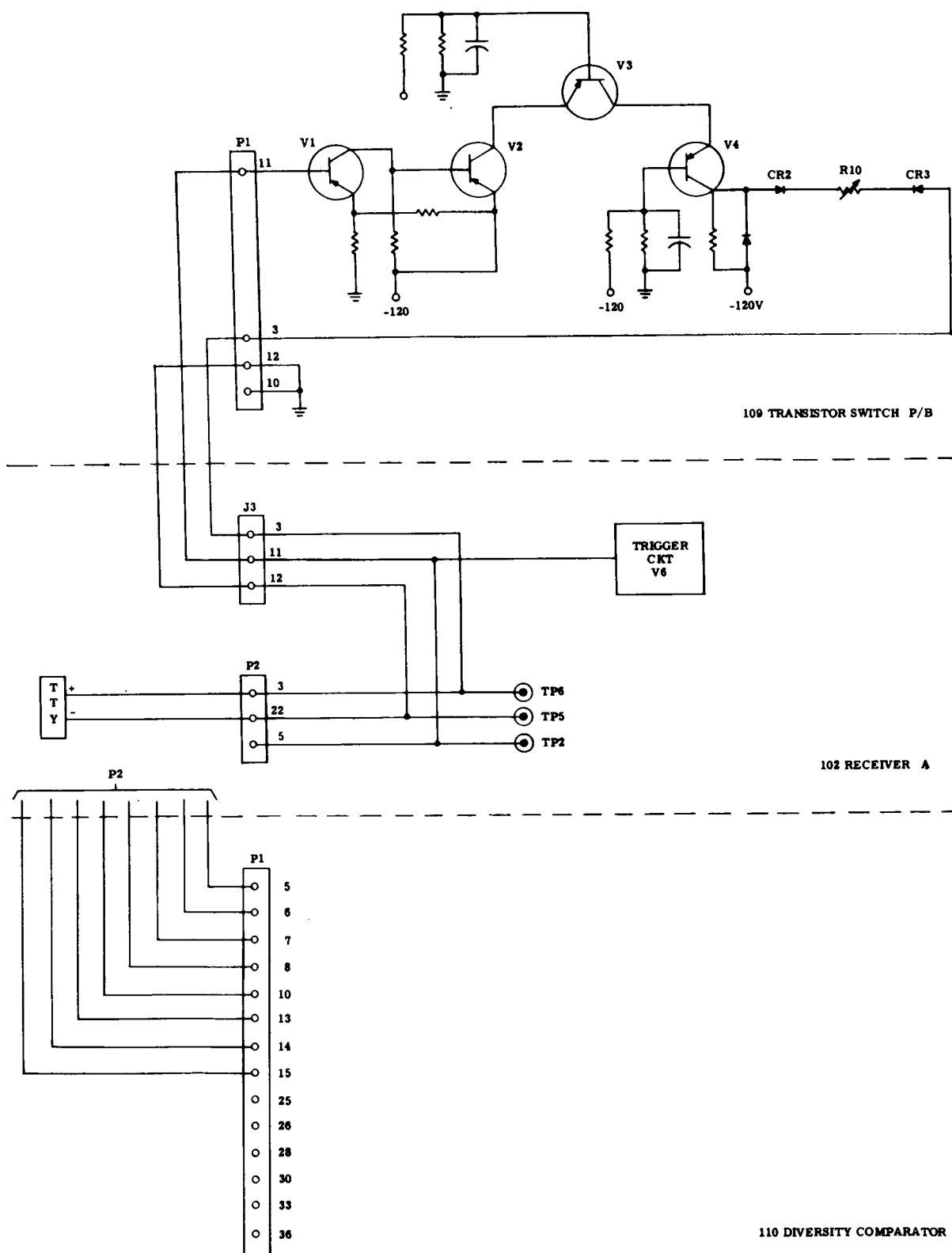


FIGURE 2-7. TONE RECEIVING EQUIPMENT CONNECTIONS, QUADRUPLE DIVERSITY

NASA - Langley  
April 3, 1961

MEMORANDUM For H. R. Brockett (Code DF)  
NASA-Headquarters

Subject: Manuals for Sr. Perez-Marin, INTA

Reference: Your Memorandum, 3/21/61

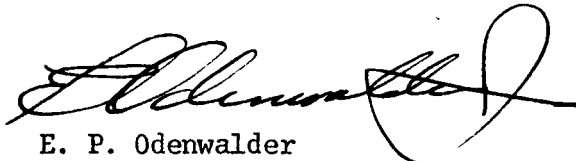
NASA Mail Sec. APR 5 1961	
TO:	DF
FROM:	
SUBJECT:	
DATE:	
TIME:	
PLACE:	
REMARKS:	

1. We have already sent you six copies of MG-101 and a copy of MDT-130.

2. Latest status on the final system manuals you requested is:

MS-101	due 4/14/61
MS-104	due 3/24/61
MS-107	Attached
MS-108	due 3/22/61
MS-109	due 3/22/61
MS-114	due 3/24/61

3. As the final versions of these system manuals come in we will forward a copy to you for Sr. Perez-Marin.

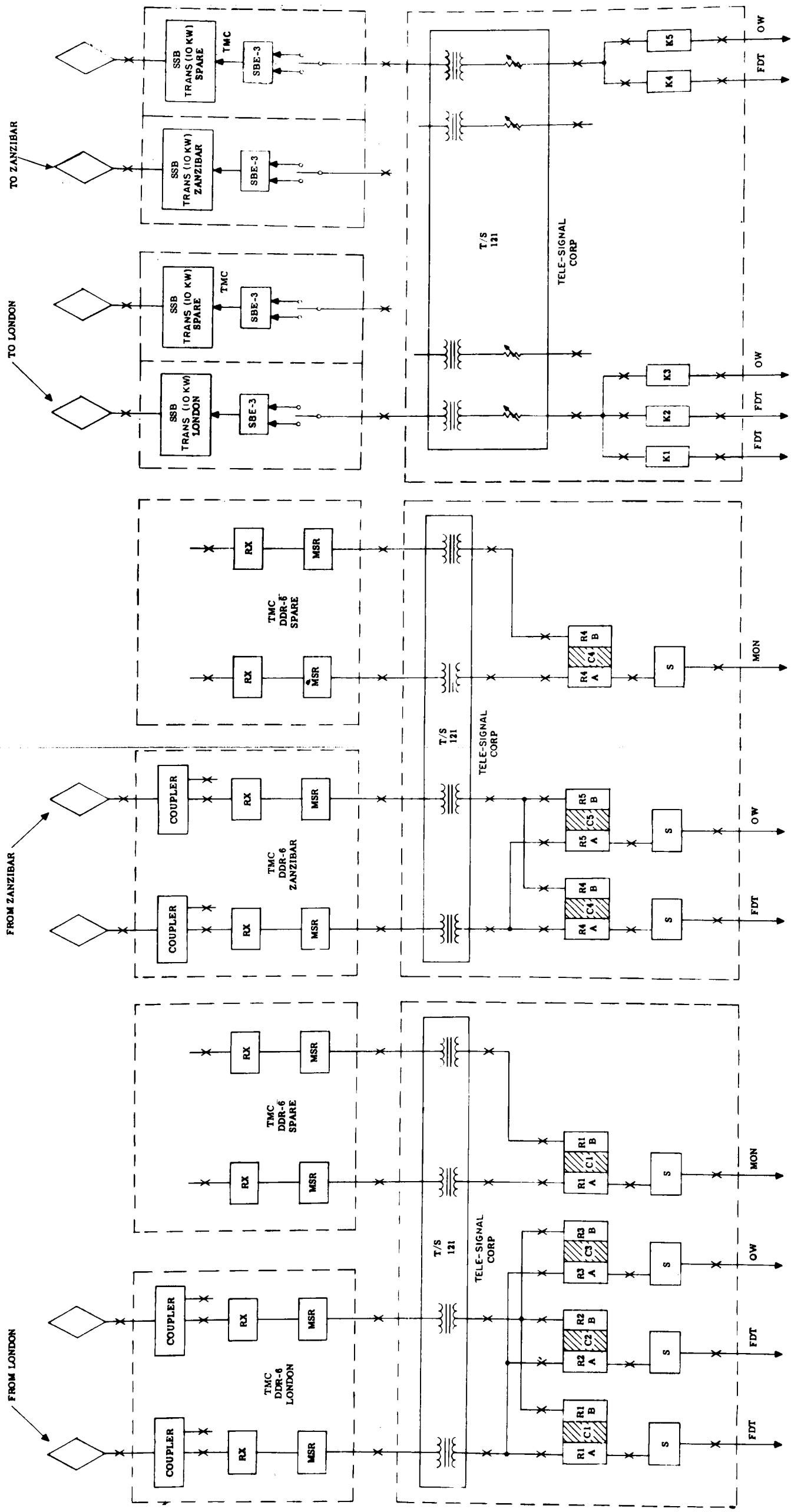


E. P. Odenwalder  
TAGI Unit

EPO.drh

GBG

Attach: 1 copy (MS-107)



TELETYPEWRITER EQUIPMENT

- NOTES:
- X PATCH JACKS
  - R TONE RECEIVERS (T/S 102)
  - K TONE TRANS (T/S 101)
  - S TRANSISTOR SWITCH (T/S 109 PB)
  - C DUAL DIVERSITY COMPARATOR (T/S 110)

FIGURE 2-8. KANO SITE, EQUIPMENT BLOCK DIAGRAM

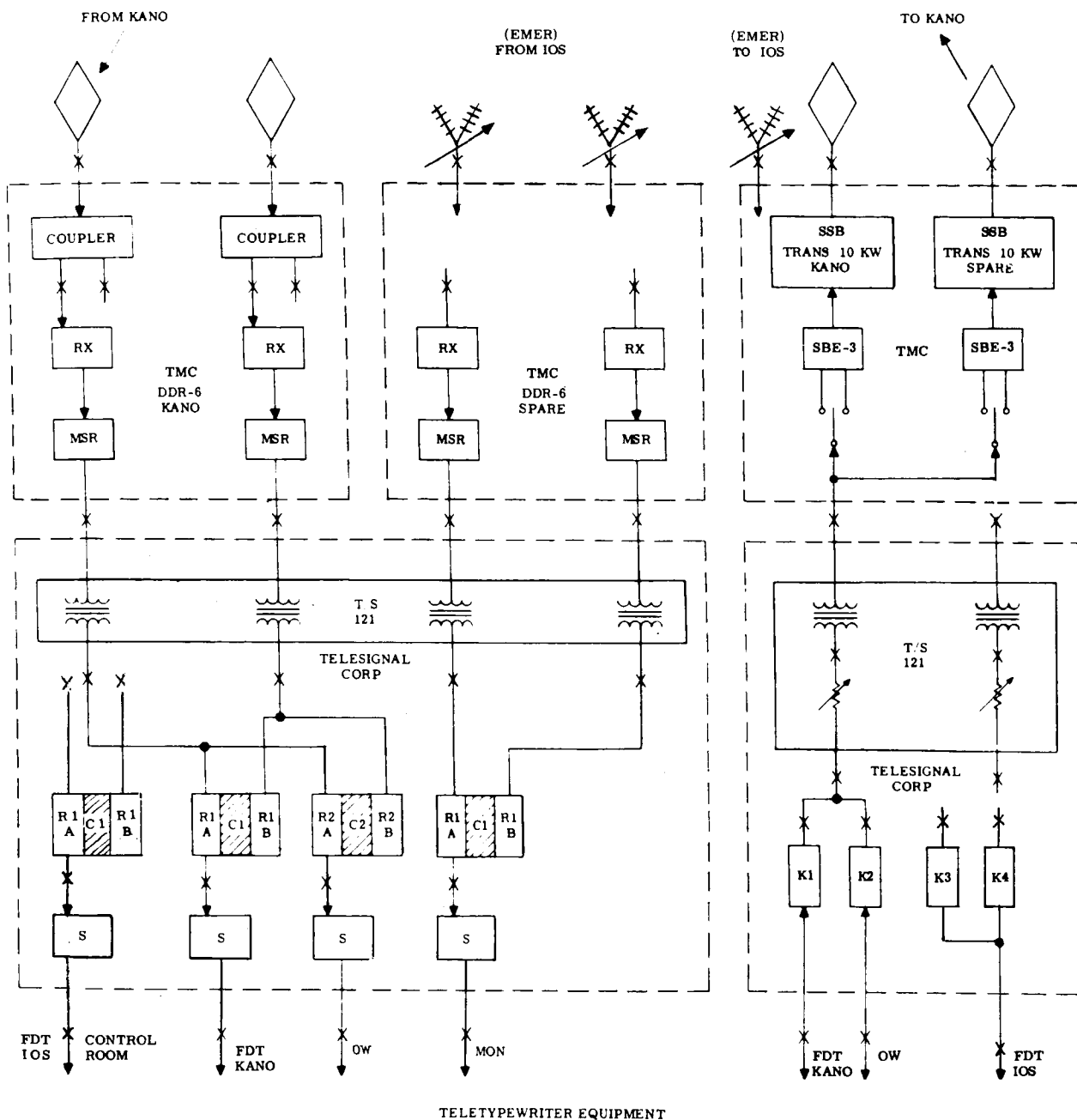
### 2.2.2 Site Block Diagrams

a. *Kano*—The primary circuits at Kano are to London and consist of two FDT circuits for Project Mercury traffic and one FDT circuit for use as an operating order wire. Kano has terminal equipment and is a relay point for all traffic to Zanzibar. The circuits between Kano and Zanzibar are two FDT circuits. The site equipment is shown in Figure 2-8.

b. *Zanzibar*—The circuits to Zanzibar consist of two FDT circuits. One of these circuits is an operating order wire. The traffic to Zanzibar is relayed through Kano. The equipment is primarily terminal equipment. However, an additional antenna system, steerable toward the Indian Ocean Ship, is provided for the Zanzibar site. This would allow the stand-by equipment to be used in establishing an emergency link to the ship site, if required. The Zanzibar site equipment is shown in Figure 2-9.

c. *Atlantic Ship*—Primary circuits to the Atlantic Ship are provided by hf radio from New York. These circuits are two FDT, one of which is used as an operating order wire. The ship is equipped as a terminal as well as a possible relay point. As a relay point, it will provide an alternate route for traffic to the Canary Island site. This route consists of two FDT circuits. The ship's omnidirectional antenna system lends itself to this relay operation. Site equipment is shown in Figure 2-10.

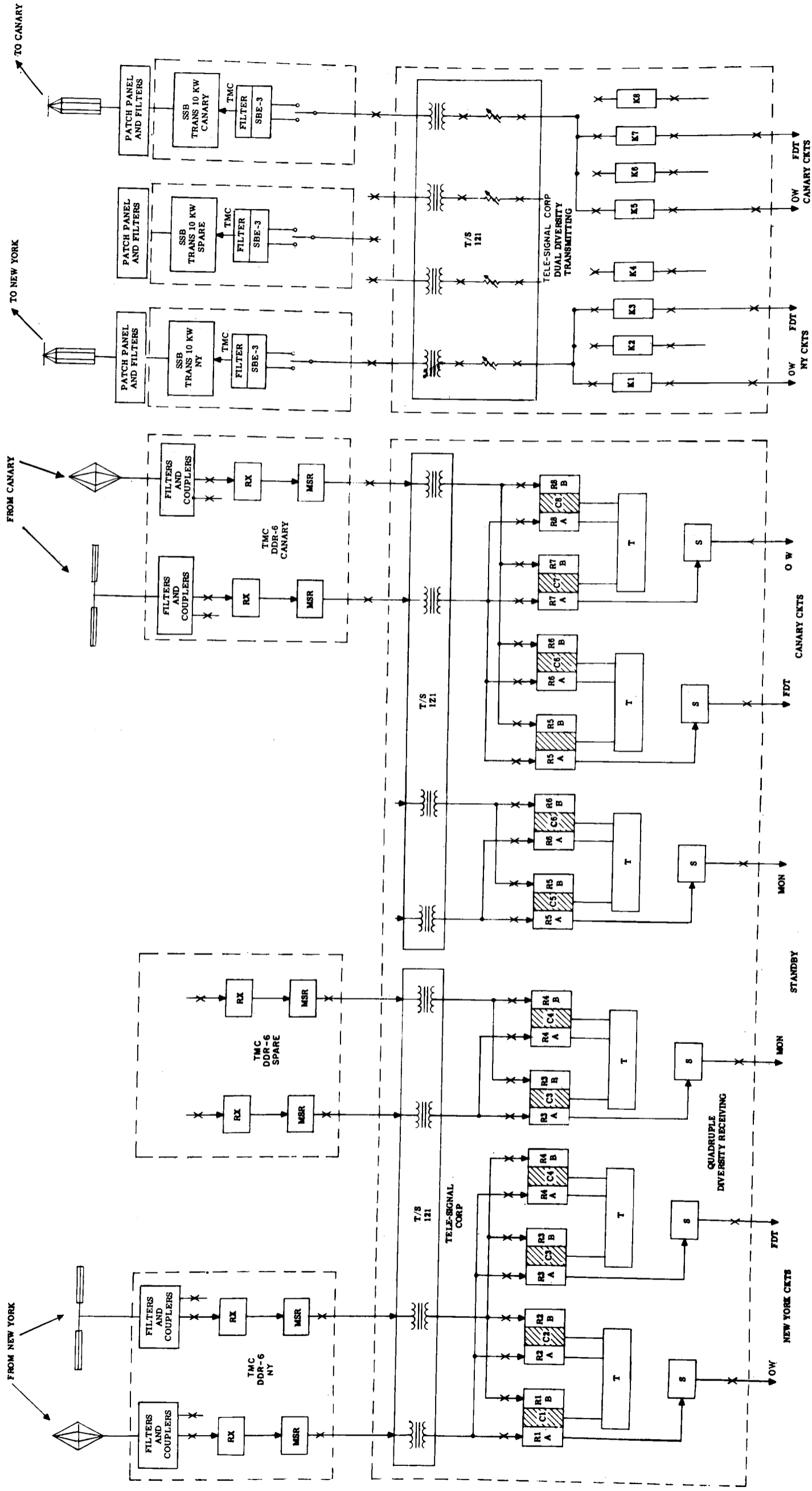
d. *Indian Ocean Ship*—The Indian Ocean Ship circuits terminate at the site and the traffic is relayed through Perth, Australia. The circuits are two FDT, one of which is used as an operating order wire. No additional HF radio equipment need be installed if the site is used as an emergency link to the Zanzibar site. The stand-by equipment and nondirectional antennas will permit this operation, if required. Site equipment is shown in Figure 2-11.



## NOTES:

- X PATCH JACKS
  - R TONE RECEIVER (T/S 102)
  - K TONE TRANS (T/S 101)
  - S TRANSISTOR SWITCH (T/S 109 PB)
  - C DUAL DIVERSITY COMPARATOR (T/S 110)
- SEE MS-109 FOR INTRASITE MUX AND UHF RADIO EQUIPMENT

FIGURE 2-9. ZANZIBAR SITE, EQUIPMENT BLOCK DIAGRAM



NOTES:  
X PATCH JACKS  
R TONE REC T/S 102  
K TONE TRANS T/S 101  
S SWITCH 109  
T TWINNING UNIT T/S 110  
C DO COMPARTOR T/S 110

TELETYPEWRITER EQUIPMENT

\* SPARE EQUIPMENT

FIGURE 2-10. ATLANTIC SHIP, EQUIPMENT BLOCK DIAGRAM

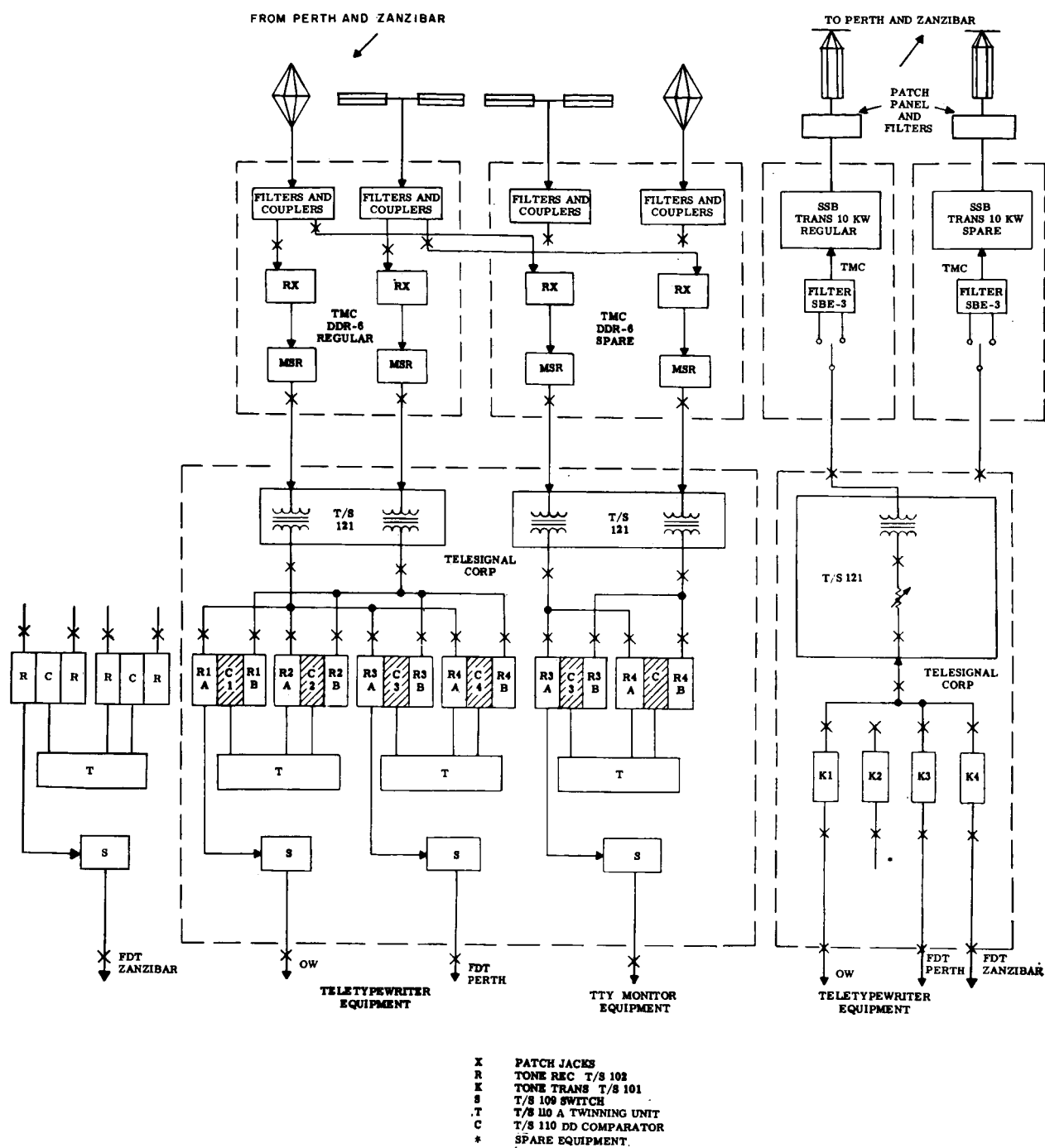


FIGURE 2-11. INDIAN OCEAN SHIP (QUADRUPLE DIVERSITY), EQUIPMENT BLOCK DIAGRAM

## SECTION 3. OPERATION

### 3.1 GENERAL INFORMATION

The operation of the point-to-point radio systems at Kano, Zanzibar, Atlantic Ship, and Indian Ocean Ship sites involves the operation of many system components. The detailed operating procedure of each component, as given in the associated equipment manual, should be thoroughly reviewed. The system operation involves the following components:

- a. Antenna coupler circuits (MS-121, *Outside Plant*, Section 2, Radio-Transmission Lines).
- b. Single sideband transmitter, mode selector, and tone transmitters.
- c. Dual diversity receivers, mode selectors, VOX units, and tone receiving equipment.
- d. Patching units for antennas, audio circuits, and dc output circuits.

### 3.2 OPERATING PROCEDURES

#### 3.2.1 Turn-On and Turn-Off

The turn-on and turn-off operations are done on a unit or rack basis rather than a system basis. This procedure is covered in the equipment manuals for the respective units. Several points should be noted, however:

- a. The power should be initially applied to the VOX units 72 hours prior to calibration and use. This will allow the frequency to stabilize. The oscillator circuits or other frequency determining devices should be left operating, if possible. The other units of equipment should be allowed a 24-hour warmup period prior to final adjustment. The ON/OFF switch of the DCP-1 power panel of each DDR-6 rack controls the power of all units except that of the VOX unit. The power to this unit is controlled on the front panel of the VOX unit.
- b. If it is necessary to turn off the transmitter, it can be completely shut down (except the blowers) by operating the filament control

switch. The minor units of equipment can be shut down by operating their respective power switches. The rack mounted equipment may have several switches to remove filament and/or plate power from all units. When the equipment has cooled and the blowers have shut down, the primary power may be removed at the load center.

#### 3.2.2 Calibration and Adjustment

Calibration is not required on a system basis although some unit calibration is required. Equipment manuals cover specific calibration procedures for the transmitting mode selector (SBE-3), variable frequency oscillator (VOX), and the GPR-90 receivers.

Adjustment on an over-all basis will follow the initial calibration and adjustment. A channel provided to each site will be used as a teletype order wire for system adjustment, lineup, and testing. System readjustment on a periodic basis will be required for corrective purposes and to determine that the system is functioning properly.

Sections 12 and 13 of MG-102, *Plant Operating and Maintenance Procedures*, establish the methods and procedures that must be used in making circuit checks. They also explain the duties and responsibilities involved in performing these checks.

#### 3.2.3 Operation

The receiving system unit operation is covered in detail in the equipment manual entitled ME-706 *Technical Manual for Receiving Set, Radio, DDR-6*. The operation of the various units of the transmitting system is covered in ME-704. Familiarization with each of the controls, their functions, and their adjustment is of paramount importance. The operating personnel must prepare tuning charts (including knob settings, positions, and calibration points) for each frequency of operation, and to record information

pertinent to each specific installation. There are fewer controls associated with the operation of the tone equipment. These controls are covered in the Tele-Signal Corporation F/S tone equipment manual ME-701 and must be thoroughly understood.

The transmitting system operation will follow the procedures outlined in the equipment manual under general procedures adjustment for single sideband operation and carrier insertion procedure. The IPA and PA tuning procedures are covered in Volume I of the equipment manual. Some transmitting adjustments such as sideband selection, frequency assignment, and operating levels of carrier and tone signals will require specific procedures. The transmitter tuning procedure is outlined in paragraph 3.2.3.1 which follows.

#### 3.2.3.1 SBE Initial Adjustments

Step	Operation	Designation	Figure
1	Install mf crystals in oven.		
2	POWER ON-OFF to ON (1 hour).	90	3-1
3	METER SW switch to CAL and zero meter with screwdriver adjustment.	94	3-1
4	XMTR switch to OFF.	88	3-1
5	VOX GAIN control and SQUELCH control counterclockwise.*	103	3-1
6	EXCITER ON-STANDBY switch in ON position.	89	3-1

\* Voice operated circuit, not used for Mercury.

#### 3.2.3.2 Transmitter Adjustments (Preliminary Notes)

Insert shorting unit HFS-DS, in place of the PA filter for initial tuneup.

The transmitter is equipped with screen overload relays, plate overload relays, circuit breakers, and the TUNE-OPERATE switch in order to provide a high degree of protection to the transmitter during tuneup. The latter permits tuning the IPA and the PA plate tank circuits on half (TUNE position) or full (OPERATE position) screen voltage. Loading these stages, however, is done with the switch in the OPERATE position. The heavy-duty vacuum tubes in these stages receive maximum protection by

tuning the IPA and PA plate tank circuits with the TUNE-OPERATE switch in the TUNE position and then loading/retuning the circuits with the TUNE-OPERATE switch in the OPERATE position. Tuning/loading a GPT-10K transmitter with the TUNE-OPERATE switch in the OPERATE position only is reserved solely for the skilled operator using a transmitter and its associated antenna for which there is an accurate tuning chart.

#### 3.2.3.3 Transmitter Tuning/Loading on Carrier

Regardless of the mode of operation desired of the GPT-10K transmitter, it is recommended that the equipment units located in the main frame chassis be initially tuned/loaded on carrier. Afterwards, the initial adjustments may be refined, according to the mode of operation desired, in order to meet rated power output and distortion requirements.

#### 3.2.3.4 Transmitting Mode Selector Lineup (SBE-3)

The transmitting mode selector model SBE is arranged for transmitter tuning/loading on carrier. If details are required, consult ME-704. Otherwise perform the following:

#### NOTE

During the entire tuning/loading procedure, check at all times that (a) the PA SCREEN CURRENT reading on meter 2 never exceeds about 35 milliamperes, (b) the PA PLATE CURRENT reading on meter 3 never exceeds about 1.5 amperes, (approximate).

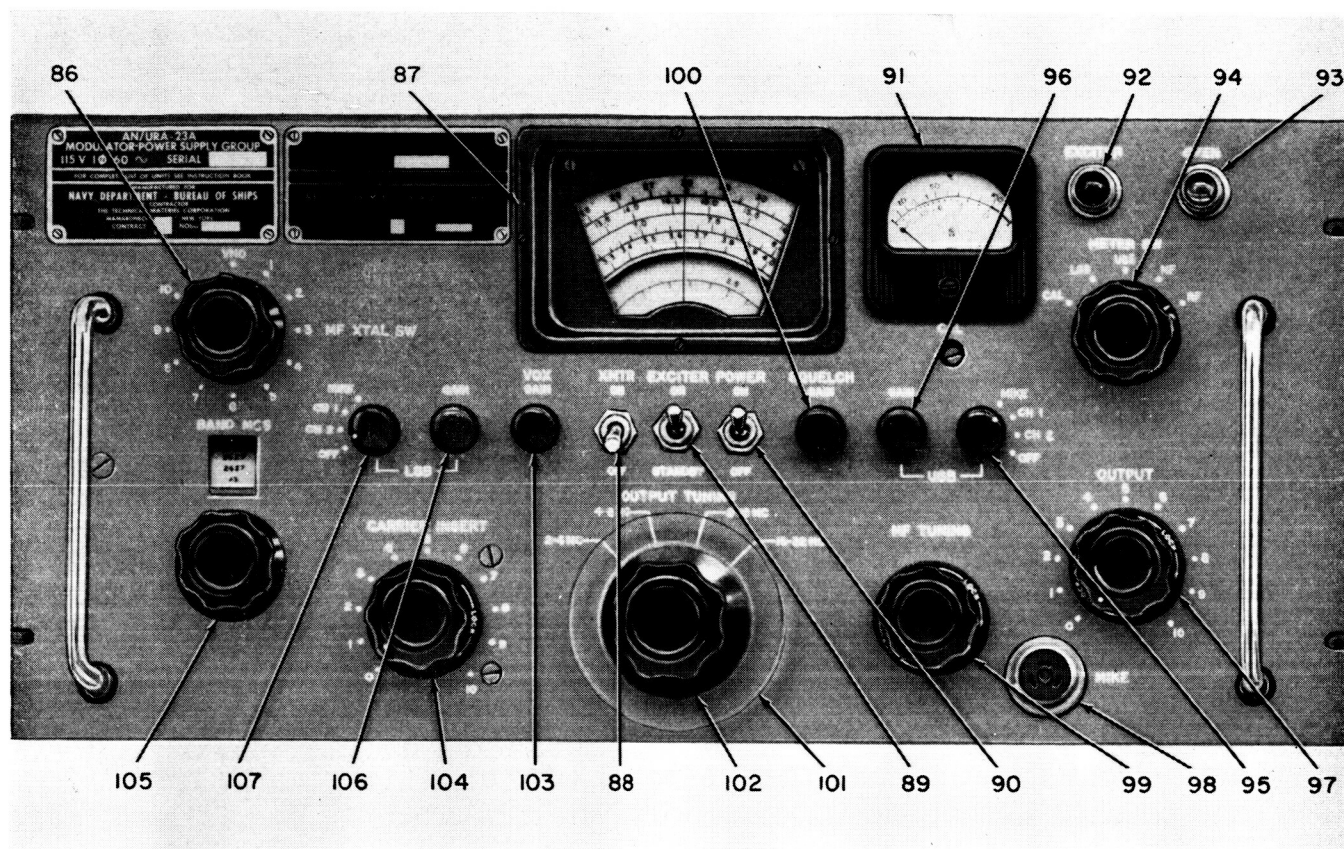


FIGURE 3-1. TRANSMITTING MODE SELECTOR SBE-3

mately 0.75 ampere at start of loading procedure), (c) the PA PLATE RF reading on meter 4 never exceeds about 5 kv, (d) the IPA PLATE current never exceeds about 400 milliamperes (approximately 275 milliamperes at start of loading procedure), and (e) the IPA SCREEN

current is generally less than 15 milliamperes. A careful tuneup under these limiting conditions, plus the transmitter's protective features, will provide the transmitter with necessary protection.

Step	Operation	Designation	Figure
1	Position the LSB/USB switch to OFF.	95,107	3-1
2	Position the MF XTAL SW switch for the selection of the correct mf crystal* or VMO if no crystal is used.**	86	3-1

<i>Step</i>	<i>Operation</i>	<i>Designation</i>	<i>Figure</i>
3	Position the BAND MCS switch for the correct output frequency per its dial scale.	105	3-1
4	Turn the CARRIER INSERT control fully clockwise; turn METER SW switch to MF.	104,94	3-1
4A	Adjust VMO (VOX) output control for a midscale reading of the SBE meter.***		
5	Position the OUTPUT TUNING switch as follows: (a) black knob (coarse setting) for proper band and (b) large disc (vernier setting) for a slightly below the desired output frequency (approximately 50 kc below).	102,101	3-1
6	Operate the MF TUNING knob to maximize the SBE meter reading (METER SW switch on MF).  Decrease the CARRIER INSERT control setting as necessary to avoid an offscale reading.	99,104	3-1

**NOTE**

The reading on the single-scale dial above the OUTPUT TUNING knob should agree with the frequency of the mf crystal, or the VMD setting.\*\*

7	Turn the METER SW switch to RF; adjust OUTPUT control as required.	94,97	3-1
8	Now advance the OUTPUT TUNING vernier switch slightly to peak the reading on the SBE meter.	101	3-1

**CAUTION**

Several peaks, due to modulation products, are possible. The correct (lower sideband) peak is the first one encountered as the vernier switch is slightly advanced.

Step	Operation	Designation	Figure
9	Operation of the OUTPUT knob will control the magnitude of the rf output. The SBE is now tuned. Turn the OUTPUT knob fully counterclockwise until the SBE's rf excitation is needed for transmitter tuneup.****,‡	97	3-1

\* For an rf output of 11 mc, the MF XTAL SW switch should select a  $(2.000 \times 7-11.000 + 0.250)$  or 3.250-megacycle crystal. The BAND MCS switch should be set at position 7. The OUTPUT TUNING knob is turned to the 8-16 mc position (coarse setting) and its vernier is turned to a dial reading slightly below the desired 11-mc output frequency. With the METER SW switch in the MF position, perform step 6 above. With the METER SW switch in the RF position, perform steps 8 and 9 above.

\*\* VOM 15 designated VOX-3 on front panel nameplate.

\*\*\* If SBE meter goes off scale, readjust VOX output control.

\*\*\*\* In the transmitter tuneup procedure that follows, in order to decrease the sensitivity of the OUTPUT knob, the CARRIER INSERT control setting may be decreased.

‡ The model SBE has more than sufficient drive to properly tune/load the transmitter. Keep the rf output low enough to satisfy the following limits.

PA PLATE dc	0.5 to 1.0 ampere (start of loading operation) 1.5 to 1.75 amperes (end of loading operation)
PA SCREEN dc	25 to 35 mil
IPA PLATE dc	300 to 400 mil
IPA GRID rf	10 to 15 volts
PA PLATE rf	5 kv

### 3.2.3.5 Transmitter (RF) Lineup

*Tuning/Loading IPA and PA Units*—In the tabulation that follows, the panel serial designations are explained in Table I, subject, Table of Equivalent Designations; two tuning charts,

one for balanced and one for unbalanced output operation, are presented in the tuning chart tables 3-2 and 3-3, respectively, in ME-704 or as explained in the footnote (\*) to the following tabulation.

Step	Panel Serial Designation	Operation	Purpose	Section 3 Figure
1	15, 16, 17, 18, 19, 23, 24, 25, 26, 27, 28, 30	Set these 12 tuning devices as per tuning chart for the desired RF output frequency.*	Approximately tunes first and second amplifiers (IPA PA) for desired RF output frequency.	3-2 3-3

\* Tuning chart, typical setting and readings supplied by manufacturer for each transmitter or see Tables 3-2 and 3-3 of equipment manual ME-704.

<i>Step</i>	<i>Panel Serial Designation</i>	<i>Operation</i>	<i>Purpose</i>	<i>Figure</i>
2	40, 41	Set PA SCREEN and HIGH VOLTAGE switches to OFF position.	Makes PA inoperative.	3-4
3	37, 39	Place TUNE/OPERATE switch in TUNE position. ALDC switch in OFF position.	Preparation for step 13.	3-4
4		Make sure the transmitter is connected to an antenna or a dummy load.	Preparation for step 19.	
5	32, 6	Turn MAIN POWER switch (32) to ON position. Check that indicator (6) lights.	Energizes linear amplifiers.	3-4 3-2
6	22	Turn MULTIMETER switch to RF 1st Amp $E_p$ .	To measure plate RF voltage.	3-3
7	20, 24, 97	Turn the model SBE OUTPUT switch clockwise as necessary to tune the first amplifier and plate tank circuit to resonance.	Maximize reading on 20. (If off scale, reduce SBE output).	3-1 3-3
8	22	Turn MULTIMETER switch to RF IPA $E_g$ .	To measure grid rf voltage.	3-3
9	20, 23	Tune to resonance. (IPA GRID TUNING)	Maximize reading on 20. (If off scale, reduce SBE output).	3-3
10	97	Turn the model SBE OUTPUT control fully counterclockwise.	Preparation for steps 11 and 12.	3-1
11	33	Push OVERLOAD RESET switch to place the relays in the relay panel in RESET position.	The timer should, by now, have operated to close the interlock circuit.	3-4
12a	34, 35, 41	Check that HIGH VOLTAGE switch (41) is in OFF position. Place INTERLOCK switch (35) in NORMAL position. INDICATOR (34) should light if all interlock circuits are closed.	Checks condition of the interlock circuits.	3-4
12b	34, 35, 41	If INDICATOR (34) does not light, turn the INTERLOCK switch counterclockwise to the last position in which the lamp is not lighted.	Locates position of the switch which causes the interlock circuit to be open.	3-4

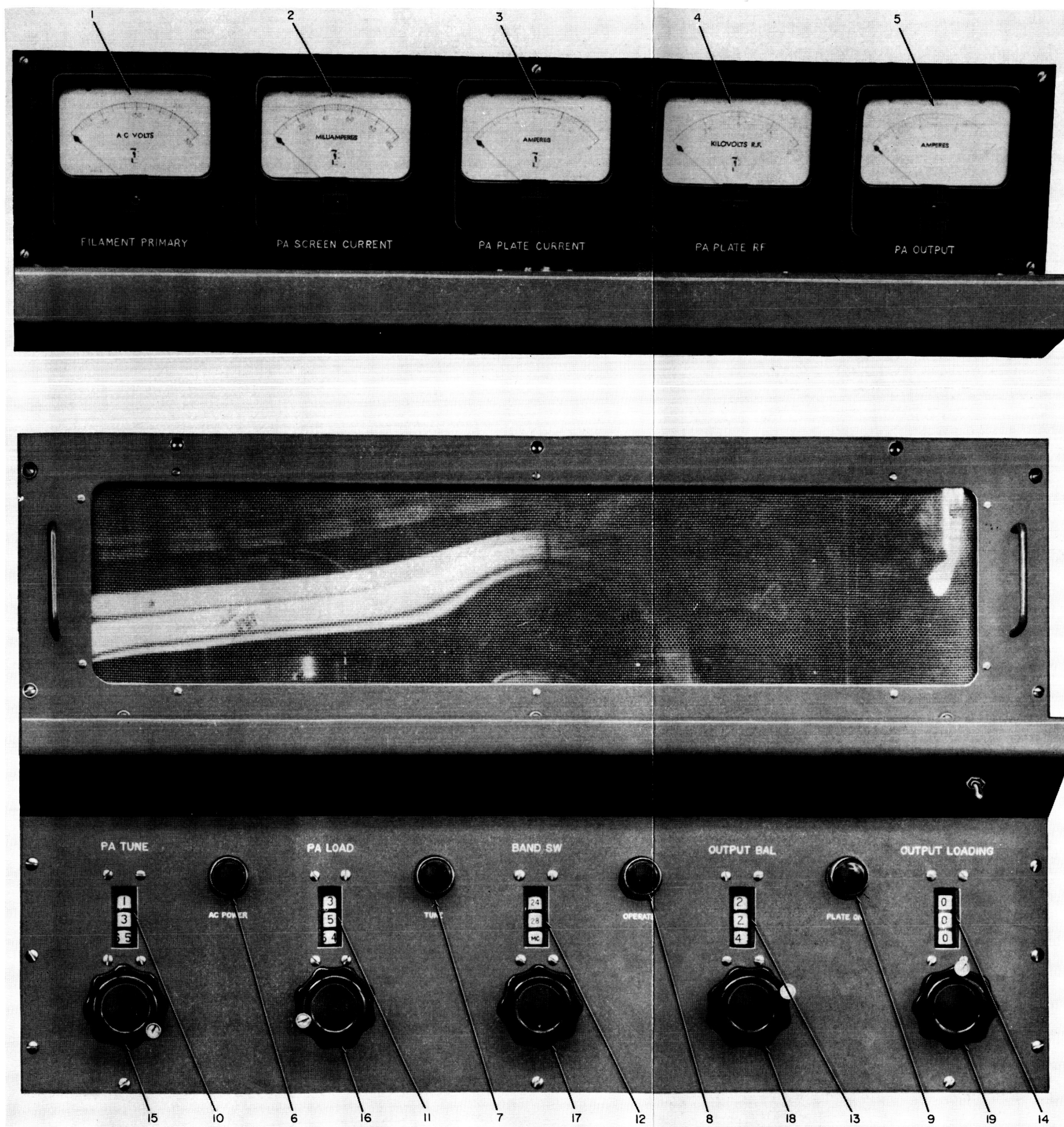
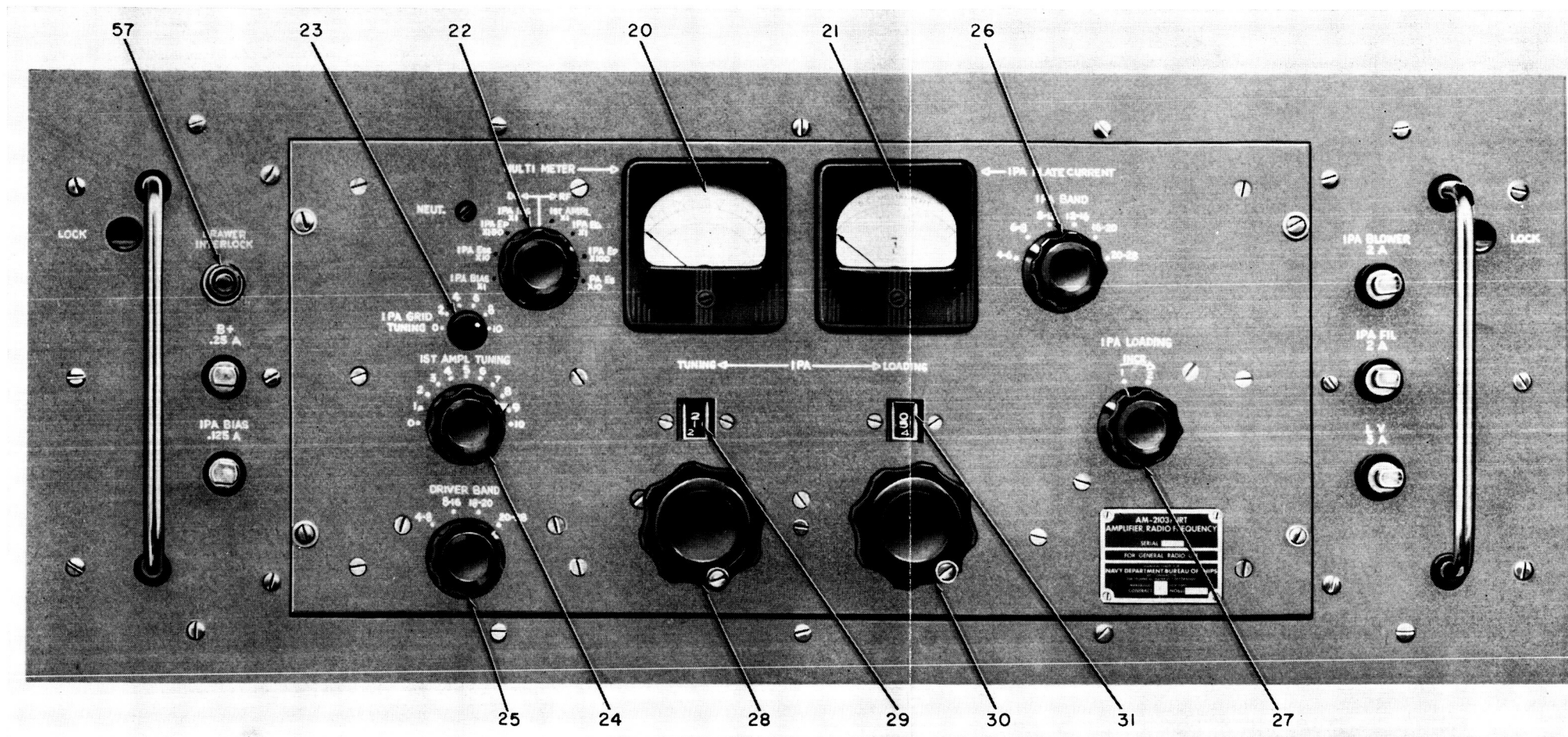


FIGURE 3-2.  
POWER AMPLIFIER PA



**FIGURE 3-3. RF AMPLIFIER IPA**

<i>Step</i>	<i>Panel Serial Designation</i>	<i>Operation</i>	<i>Purpose</i>	<i>Figure</i>
12c	34, 35, 41	Close the switch which causes the interlock circuit to open. Repeat steps 12a and 12b until INDICATOR (34) lights when INTERLOCK switch is in NORMAL position.	Checks normalcy of the interlock circuits. The transmitter is now ready for high voltage power supply.	3-4
13	41, 9, 40, 39	With PA SCREEN (40) in the OFF position and TUNE-OPERATE switch (39) in the TUNE position, turn the transmitter HIGH VOLTAGE switch (41) to the ON position. PLATE ON indicator (9) on the top of the transmitter should light.	The IPA and PA amplifiers now receive full plate voltage, and the IPA amplifier receives half screen voltage (200).	3-4 3-2
14	21, 97	Turn the model SBE OUTPUT control (97) clockwise until some increase is observed in the IPA PLATE CURRENT ammeter (21).	Preparation for step 15.	3-3 3-1
15	28, 21	Tune the IPA plate tank to resonance by turning IPA TUNING control (28).	Obtain dip on the IPA PLATE CURRENT ammeter 21 reading.	3-3
16	97	Turn the model SBE OUTPUT control fully counterclockwise.	Preparation for step 18.	3-1
17	40	Turn PA SCREEN switch to the ON position.	Preparation for step 19.	3-4
18	3, 97	Turn the model SBE OUTPUT control clockwise until an increase is observed in the PA PLATE CURRENT meter.	Preparation for step 19.	3-2 3-1
19	3, 15	Tune the PA plate tank to resonance by turning PA TUNE knob (15).	Obtain a dip on the PA PLATE CURRENT meter (3) reading.	3-2
20	97	Turn the model SBE OUTPUT control fully counterclockwise.	Preparation for loading and re-tuning the transmitter.	3-1
21	39, 40, 41	Check that the HIGH VOLTAGE circuit breaker is in the ON position: PA SCREEN switch (40) is in the ON position: turn TUNE-OPERATE switch (39) to the OPERATE position.	The IPA tube is now energized with 400 (screen) and 3000 (plate) voltages. The PA tube is now energized with 1200 (screen) and 7500 (plate) voltages.	3-4

Step	Panel Serial Designation	Operation	Purpose	Figure
22		Repeat steps 6 and 7.**	First amplifier is retuned.	
23		Repeat steps 8 and 9.**	Second amplifier is retuned.	
24		Repeat steps 14 and 15.	IPA is retuned.	
25	27, 28, 30, 21, and SBE OUTPUT, 97	Load the IPA to approximately 275 milliamperes on 21. (Use 27, 30, and SBE OUTPUT as necessary). Simultaneously maintain resonance in the IPA plate tank circuit. (See step 24.) This loading will subsequently be increased as the following RF circuits are tuned to load the antenna.	As 30 is moved in small steps, 28 is moved to dip the PLATE CURRENT meter (21) reading. Hence the IPA is gradually loaded concurrently with plate tank circuit resonance. Simultaneously maintain the IPA grid rf within the limits specified above (10 to 15 volts).	3-3 3-1
26a	3, 15, 16, 18, 19	The general objective of this step is to load the PA stage to obtain the desired power output, using PA LOAD knob (16), OUTPUT BAL knob (18), and OUTPUT LOADING knob (19), while concurrently maintaining resonance with PA TUNE control knob (15). Power output is indicated by PA output current squared, times the output impedance (600 ohms) and is doubled for a PEP reading.	Step 26a assumes balanced transmitter operation. For more details, see following remarks. In balanced transmitter operation, knobs 18 and 19 control the L section impedance, as explained in paragraph 4-4-b in ME-704.	3-2
26b	3, 5, 15, 16, 18, 19	The general objective of this step is to load the PA stage to obtain the desired power output, using the PA LOAD knob (16), the OUTPUT BAL knob (18), and the OUTPUT LOADING knob (19), while concurrently maintaining resonances with the PA TUNE control knob (15). Power output is indicated by PA OUTPUT meter (5), squared, times the output impedance (72 ohms).	Step 26b assumes unbalanced transmitter operation. For more details, see following remarks. In unbalanced transmitter operation, knobs 18 and 19 control L section impedance as explained in paragraph 4-4-b in Section 4 of ME-704.	3-2

\*\* Caution: Do not overdrive the amplifiers.

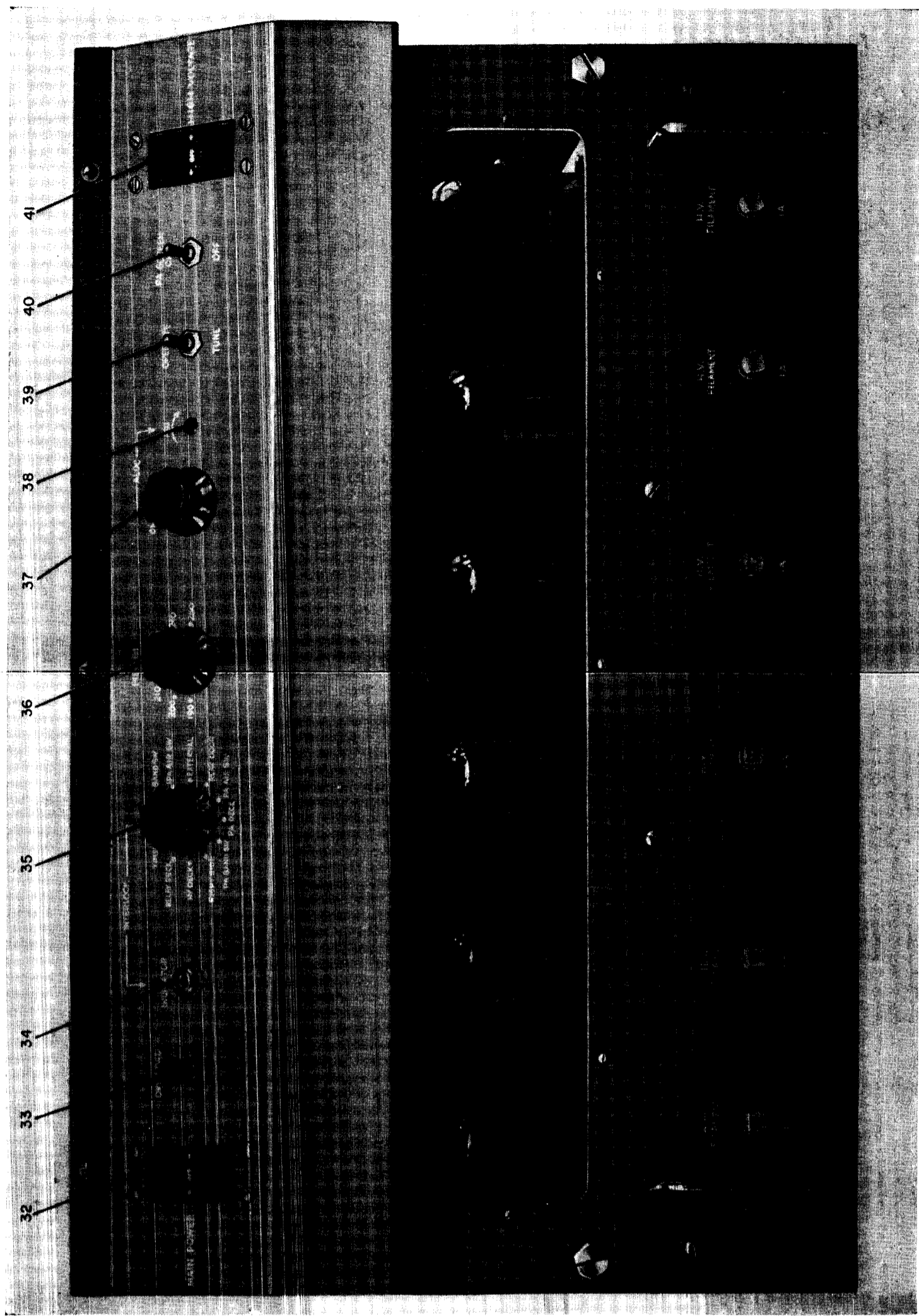


FIGURE 3-4. HV RECTIFIER AND CONTROL POWER

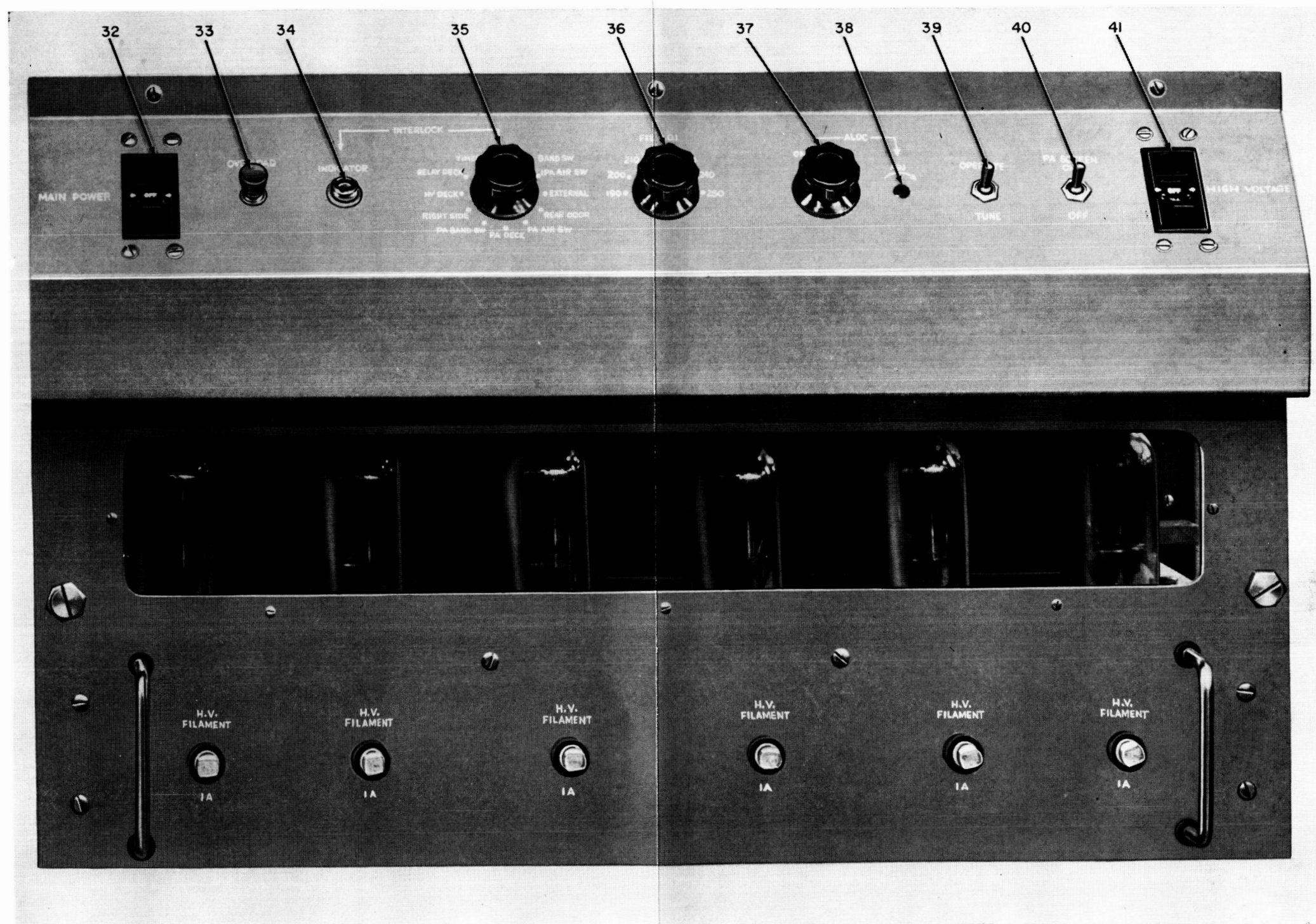


FIGURE 3-4. HV RECTIFIER AND CONTROL POWER

<i>Step</i>	<i>Panel Serial Designation</i>	<i>Operation</i>	<i>Purpose</i>	<i>Figure</i>
27a		Power output in kw equals the product of the current in one antenna meter (on top of transmitter), squared, and multiplied by 0.600 (600-ohm rhombic antenna). This means approximately 3 amperes for 5 kw (average) or 10 kw (PEP).	Balanced operation of transmitter. An actual antenna at a given frequency may have an impedance value greater or less than 600 ohms.	
27b	5	Power output in kw equals the current in PA OUTPUT meter (5), squared, and multiplied by .072 (72-ohm antenna). This means approximately 8 amperes for 5 kw (average) or 10 kw (PEP).	Unbalanced operation of transmitter. An actual antenna at a given frequency may have an impedance value greater or less than 72 ohms.	3-2
28		Replace the shorting unit, HFF-DS, with the proper PA filter, HFF-3.	The shorting unit prevents filter burnout during tuneup.	

3.2.3.6 *Single Sideband Suppressed Carrier Operation (TTG ADJUSTMENTS)*

Arrange the transmitting mode selector model SBE for transmitter tuning/loading as stated in the caption. Arrange the test generator model TTG audio output for two tones. If details are required, consult ME-704. Otherwise, proceed as follows:

<i>Step</i>	<i>Operation</i>	<i>Designation</i>	<i>Figure</i>
1	The transmitter has been tuned/loaded on carrier (paragraph 4.2.3.5). Reduce SBE's drive pending need for resumption during tuning/loading adjustments to meet distortion requirements on SSB suppressed carrier transmitter emission.	97	3-1
2	The CARRIER INSERT switch on the SBE's panel is in position 0. Subsequently, the switch may be advanced to meet requirements for either the -10-db or -20-db insertion generally used in practice to facilitate receiver operation.*	104	3-1

\* --20-db insertion will be used in Mercury operation.

Step	Operation	Designation	Figure
3	The POWER switch on the TTG is in the ON position.	147	3-5
4	The AUDIO TONE SELECTOR switch is in the TWO TONE position and the AUDIO OUTPUT control is in midposition.	149,150	3-5
5	The toggle switch CHANNEL 1 (or CHANNEL 2) on the monitor control panel model MCP is in the TONE INPUT position.	111,112	3-6
	Check also that the MCP's SBE VMO INPUT switch is in the OFF position.	108	3-6
6	The LSB (or USB) selector switch on the SBE's panel is in the CH 1 (or CH 2) position. Place the METER SW switch in the LSB (or USB) position and adjust the two-tone input to -6 db on the SBE's db meter; use GAIN control on SBE and/or AUDIO OUTPUT control on TTG as necessary to obtain this level.	107,95,94, 150,91,106, 96	3-1 3-5
7	The SBE's METER SW switch is returned in the RF position and the RF output as read on the SBE's db meter is raised to approximately meet (a) rated transmitter output and (b) about 300 to 350 milliamperes of IPA plate current.		
In the case stated in step 1, the sideband frequencies differ from the carrier frequency by the heterodyning audio frequencies. This should not affect the carrier tuning/loading appreciably.			

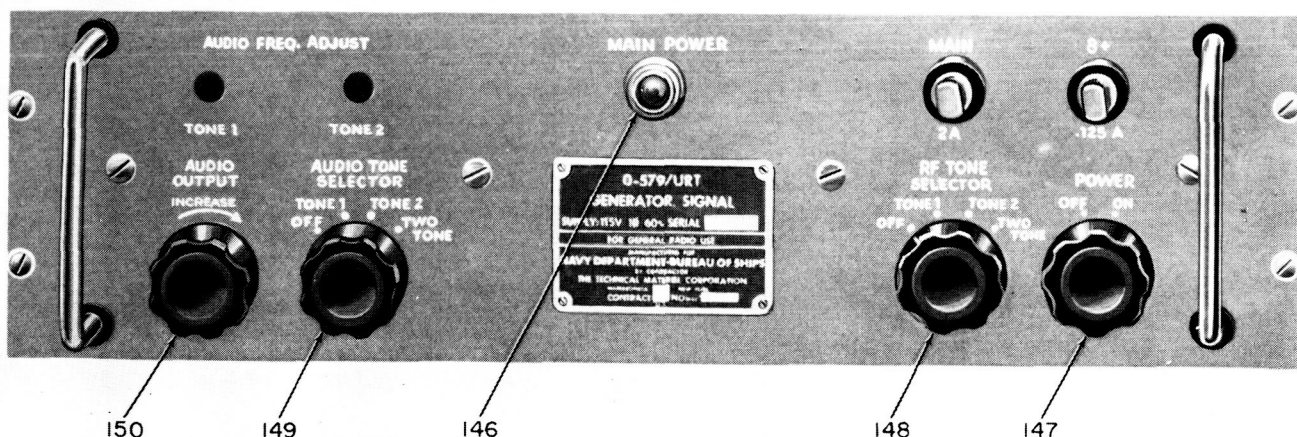


FIGURE 3-5. TWO-TONE (TEST) GENERATOR TTG

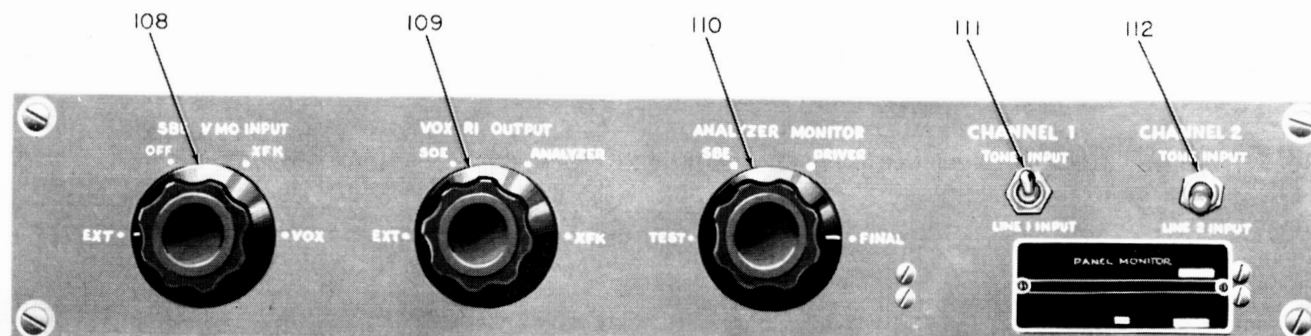


FIGURE 3-6. MONITOR CONTROL PANEL MCP

## 3.2.3.7 Analyzer (FSA) and VOX Operation

*Operation of Spectrum Analyzer*—Arrange the spectrum analyzer group model FSA for reception of PA output signals and the variable fre-

quency oscillator model VOX to supply proper injection into the analyzer. If details are required, consult ME-704. Otherwise, proceed as follows:

Step	Operation (See Note)	Designation	Figure
1	The ANALYZER MONITOR switch on the monitor control panel model MCP is in the PA or FINAL position.*	110	3-6
2	The VOX RF OUTPUT switch on the monitor control panel model MCP is in the ANALYZER (FSA) position.	109	3-6
3	The MASTER OSCILLATOR FREQUENCY knob on the VOX is set at the proper injection frequency ( $F_x$ ) into the analyzer, where $F_x = \frac{F_o + 500}{N}$ <p><math>F_o</math> = transmitter's output frequency in kc.  <math>N = 1, 2, 4, 8</math>, or <math>16</math> depending on the setting of BAND MCS switch on the VOX. For example:</p> <p>If <math>F_o</math> is 6 mc, <math>F_x</math> is <math>\frac{6500}{2} = 3250</math>;</p>	126,127	3-7

\* This switch can be placed in the SBE, IPA or DRIVER position for checking distortion in either of these units as well as in the PA as described in this table.

Note: The distortion measurement is detailed in paragraph 4.1.2 of this manual.

Step	Operation	Designation	Figure
	$\text{If } F_o \text{ is 11 mc, } F_x \text{ is } \frac{11,500}{4} = 2875;$ $\text{If } F_o \text{ is 19 mc, } F_x \text{ is } \frac{19,500}{8} = 2437.5$		
4	<p>On the VOX:</p> <p>BAND MCS switch is set in the correct band.</p> <p>XTAL FREQ switch is set in any position (not in circuit).</p> <p>XTAL switch is set in the VMO position.</p> <p>TUNING switch tunes VOX.</p> <p>OUTPUT switch is set in midposition.</p>	131,130,129 132,128	3-7

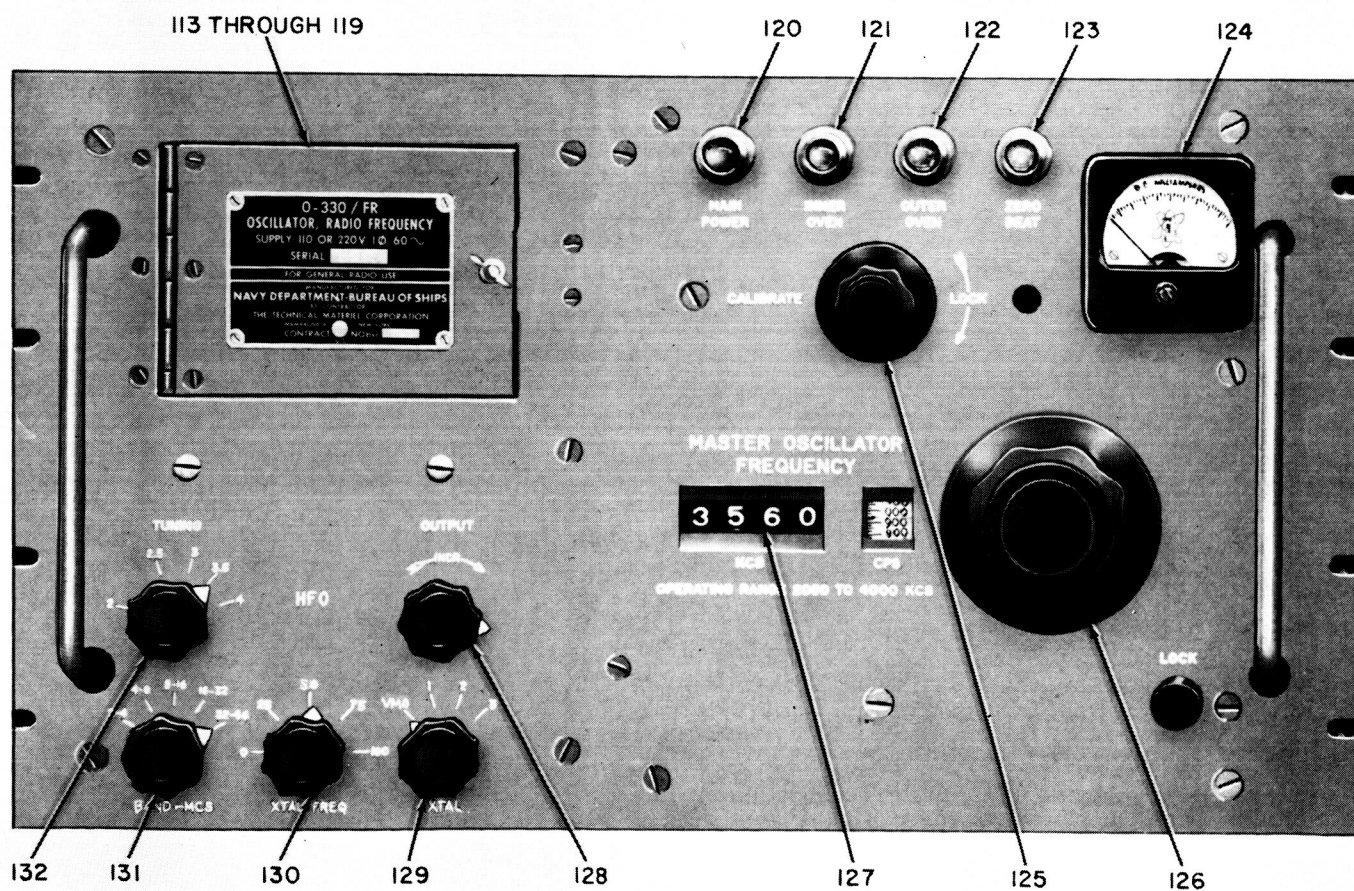


FIGURE 3-7. RF OSCILLATOR VOX

Step	Operation	Designation	Figure
5	On the FSA: IF ATTEN switch is in the 20-db position. SWEEP WIDTH SELECTOR switch is in the 10-kc position. AMPLITUDE SCALE switch is in the log position. INPUT ATTENUATOR, GAIN, AND CENTER FREQ. switches center the display from top to bottom of the scale. (Set peak of highest tone at 0 db on the log scale of the scope.)	79,78,75    67,73,74	3-8

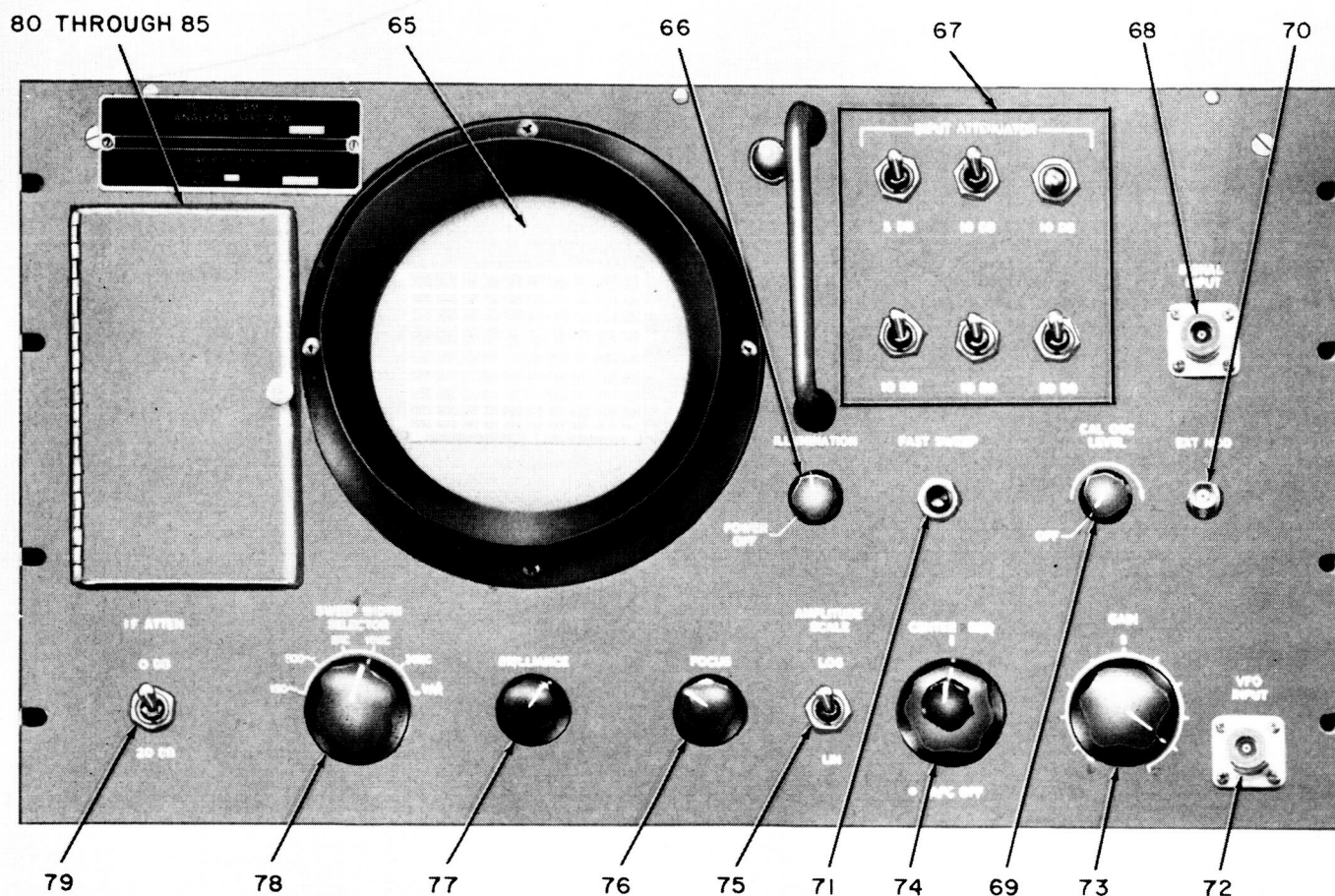


FIGURE 3-8. FREQUENCY SPECTRUM ANALYZER FSA

### 3.2.3.8 Receiving Terminal Operation

As stated in the DDR-6 equipment manual, the receiving system has been adjusted, tested, and checked out by the manufacturer prior to shipment. Barring rough handling during shipment and installation, initial adjustments, and check-out, refer to the operating procedures given below. The tuning and adjustment procedures listed below should be supplemented by the more detailed information included in the DDR-6 receiving system equipment manual, where required. The DDR-6 equipment layout is shown on Figure 1-8 of this manual.

By connecting two receivers to the two outputs of one filter, these two receivers can simultaneously receive RF signals anywhere within the -1.5-per cent acceptance band of the receiver filter.

The receivers are used in the SSB mode of operation and only the RF and IF sections are used. The HFO injection voltage is supplied by an external variable oscillator, VOX. If details are required, consult the DDR-6 equipment manual. The operation of the DDR-6 receiving terminal is similar to that of other communications receivers. However, in the DDR-6, the VOX provides HFO, IFO, and BFO signals. Two receiving equipment groups (GPR-90, MSR-6, and AFC-1) must be adjusted separately and similarly for diversity reception.

Single conversion is used for operation on the three lower receiving bands (VMO is 955 kc

above the signal frequency) and double conversion on the three upper receiving bands (VMO is 3.955 mc above the signal frequency).

The tuning procedures must be as follows:

a. Calibrate the VOX unit and adjust for type and frequency of operation.

b. Adjust receiver controls as follows:

<i>Control</i>	<i>Position</i>
HFO switch	EXTERNAL
RF SGL	NON XTAL
AUDIO GAIN	CCW
CAL	OFF
LIM	OFF
MAN/AVC	AVC
BFO	OFF
BAND SPREAD	100
SEND/REC	REC
XTAL PHASE	0
MAIN TUNING	SIG. FREQ.
RANGE SEL	CORRECT BAND
RF GAIN	CW

(The audio spread, BFO pitch, audio select, and crystal adjust controls do not apply in this operation.)

<i>Step</i>	<i>Operation</i>	<i>Designation</i>	<i>Figure</i>
<i>Radio Receiving Set (DDR-6) Adjustments</i>			
1	Tune receiver to assigned frequency.*	1,2,3	3-9
2	HFO switch to EXT.	6	3-9
3	Tune VOX to the desired frequency and output level. Example: $F_o = F_s + 0.955 \text{ mc}$ $\quad = 1.000 + 0.455$ $\quad = 1.455 \text{ mc}$ $F_o = F_s + 3.955 (1)$ $\quad = 25.000 + 3.955 \text{ mc}$ $\quad = 28.955 \text{ mc}$		(VOX shown in transmitting section)



FIGURE 3-9. RECEIVER GPR-90

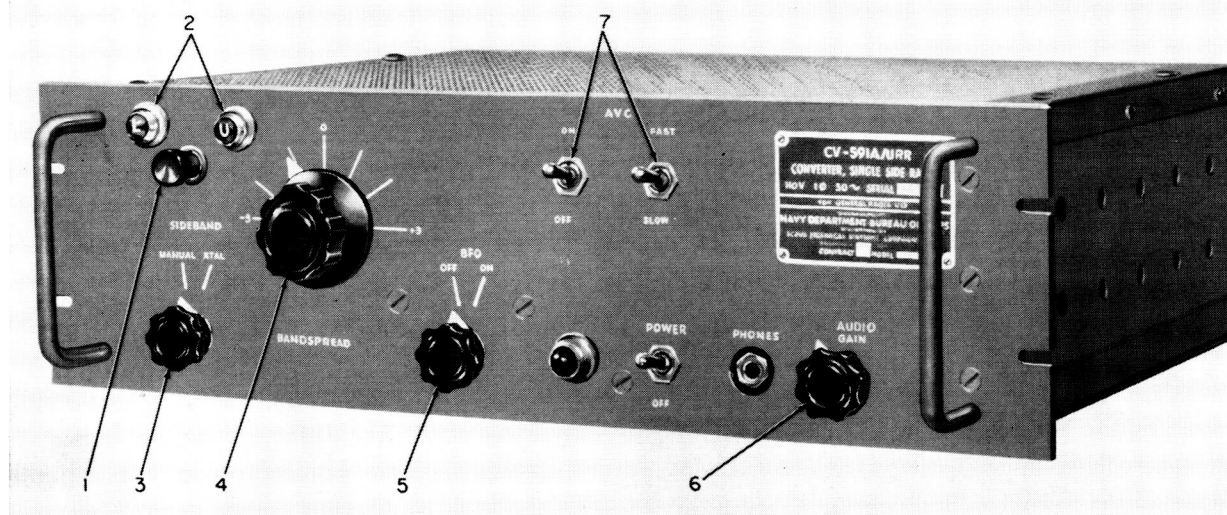


FIGURE 3-10. SSB CONVERTER MSR-6

Step	Operation	Designation	Figure
------	-----------	-------------	--------

**NOTE**

Double conversion in 5.6- to 31.5-mc range.

4	Retune receiver (bandspread), if required.	3	3-9
5	Adjust antenna tune control for maximum indication on S meter.	4,12	3-9
6	Set RF GAIN control fully clockwise.	5	3-9

*Mode Selector (MSR-6) Adjustments*

7	Press sideband select button to select proper sideband as indicated by U or L lamp.	1,2	3-10
8	Oscillator switch to MANUAL.**	3	3-10
9	BANDSPREAD dial to 0.	4	3-10
10	BFO switch to ON.	5	3-10
11	AVC switch to OFF (FAST/SLOW switch not used).	7	3-10
12	Audio gain adjusted as required in system lineup procedure (paragraph 4.2.4) for -10 db into tone receivers.	6	3-10
13	After adjustment of AFC unit, adjust BANDSPREAD dial for zero on AFC meter.	4	3-10

*Automatic Frequency Control (AFC) Adjustments*

14	Calibrate AGC circuit as follows:		
	a. CXR COMP. on 10 db.	4	3-11
	b. One-microvolt signal at receiver input.		
	c. Place T connector in coax 455-kilocycle RF output of receiver. Connect VTVM to T connector and adjust AGC potentiometer (internal) for 10 volts on VTVM.		
15	CXR COMP. to 20 db. (This may vary with system.)	4	3-11
16	AGC selector to MAN.	3	3-11

\* Advance gain control on LSP-7 and tune using audio output as an indication.

\*\* If a 438- and 472-kc crystal is supplied, crystal operation may be desired.

Step	Operation	Designation	Figure
17	Operate AFC reset button to return AFC meter to zero and discharge correction circuit. (Reset after or during each adjustment or readjustment.)	5	3-11
18	Tune receiver off frequency, and adjust ALARM ADJ. potentiometer so that FADE ALARM lamp is lighted (on noise).	6,7	3-11
19	Retune receiver to signal frequency and FADE ALARM lamp should be extinguished.	7	3-11
20	Set AGC selector to F, M, or S, as directed by circuit fading conditions (S for strong signal path conditions).	3	3-11

### 3.2.3.9 Tele-Signal Tone Multiplex Equipment Lineup

Equipment lineups for Tele-Signal model 101

F/S tone transformer and for Tele-Signal model 102 tone receiver and 110 comparator are described in Tables VII and VIII which follow.

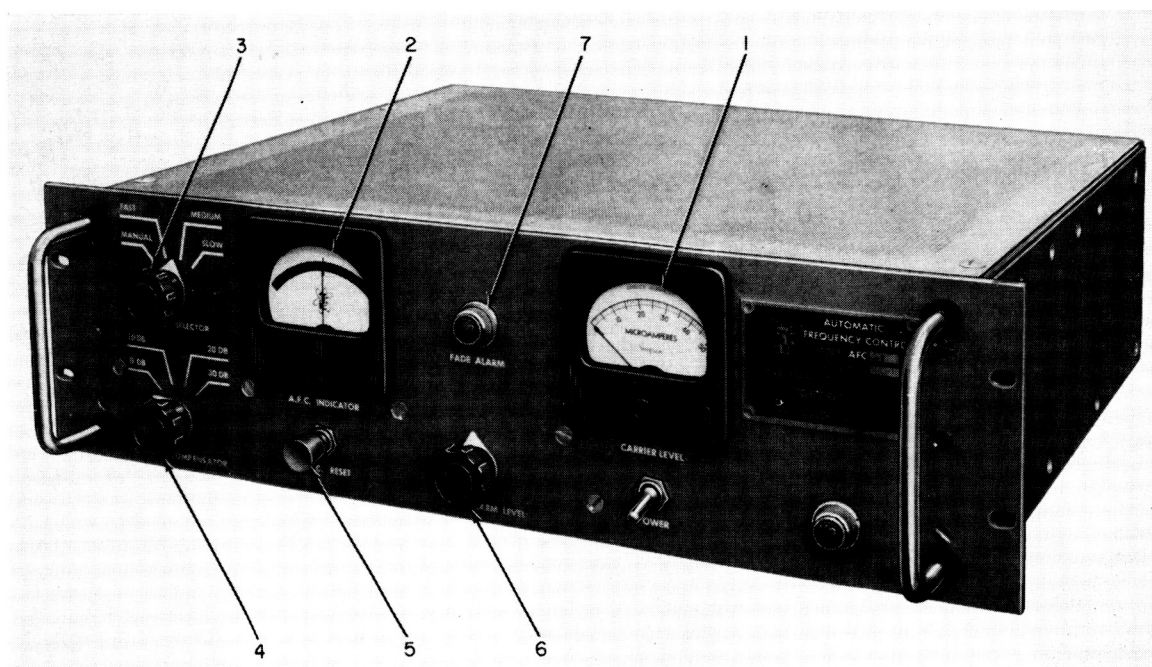


FIGURE 3-11. AUTOMATIC FREQUENCY CONTROL AFC-1

TABLE VII  
TELE-SIGNAL MODEL 101 F/S TONE TRANSMITTER LINEUP

Lineup Tests In Numerical Sequence	Purpose of Test	Channel Condition	Measuring Equipment Required	Test Points	If Neces- sary Adjust	Component of Schematic Diagram	Requirement	Remarks
1	Space fre- quency ad- justment	S-M-L switch to S	HP 521C counter	5 and 6 (5 common)	SPACE control	R105	Desired space frequency	For negative sense key- ing (inverted) where the mark frequency is low- er than the space fre- quency, adjust MARK control first. In all cases, adjust the lower fre- quency first.*
2	Mark fre- quency ad- justment	S-M-L switch to M	HP 521C counter	5 and 6 (5 common)	MARK control	R104	Desired mark frequency	
3	Gain ad- justment	S-M-L switch to L	HP 130B scope	1 and 8 (8 common)	GAIN control	R106	Set GAIN control for maximum amplitude consistent with good waveform, showing about 10-per cent clipping at the top and just starting to clip at the bottom.	TP8 is common of unit; B+*
4	Output level	S-M-L switch to L	HP 400D VTVM	4 and 5 (5 common)	OUTPUT control	R103	—10 db. The output levels of the M and S frequen- cies should be within 1 db of each other.	Transmitter output must be connected to the line.*
5								Put S-M-L switch to L for system operation.
6	Transmit- ting level adjustment	All 101 F/S tone trans- mitters on line, each —10-db out- put.	HP 400D VTVM	PAD OUT MON Jack	PAD on 121 panel		— 10 db	

\* Alignment procedure for standard networks only (section of ME-701, Tele-Signal Corporation  
Model 2000 F/S Tone Diversity System).

TABLE VIII

## TELE-SIGNAL MODEL 102 TONE RECEIVER AND 110 COMPARATOR LINEUP

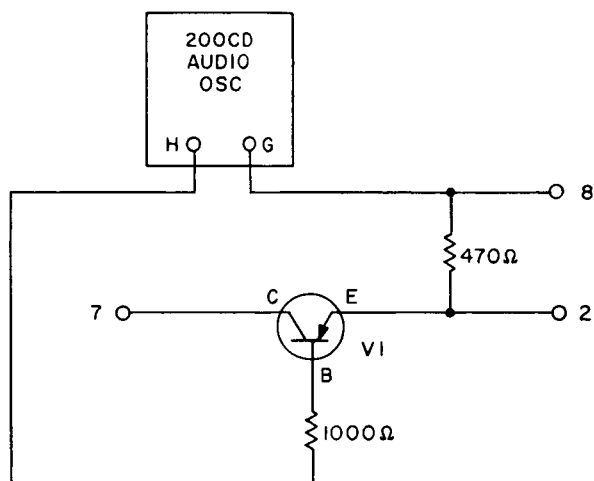
Test Step No.	Purpose of Test	Measuring Equipment	Test Points	If Necessary Adjust	Requirement and Procedure
1					Patch from TRANS KEYER OUT jack of the 101 tone transmitter through MULT jacks to RECUR/CONVT IN jacks of the normal (CHAN A) receiver and diversity (CHAN B) receiver whose operating frequencies are the same as the tone transmitter. S-M-L switch on L.
2					Patch a 100A TTY test distributor to TRANS SERIES LOOPING jack. Set 100A to send reversals.*
3					Set GAIN BAL control of the comparator to midposition.**
4					Set CHAN A LEVEL and CHAN B LEVEL controls on the comparator all the way counterclockwise.**
5	Balance	Triplett volt-ohm-milliammeter 10-volt dc scale	2 and 3	DC BAL control on comparator	OV (within 1/2 volt). **
6					Set CHAN A LEVEL and CHAN B LEVEL controls for midscale readings on both meters.**
7	Center frequency adjustment of receiver channel B	HP 130B scope. Adjust scope sweep to twice signal speed. Do not use synch. Use dc input on scope.	3 and 8 (8 is ground) of receiver channel B	C E N T E R FREQ control of REC B	Set SENSE switches on both 102 receivers to D. Set SENSE switch of comparator to +. Short out input of REC A by placing a test lead from TP1 to TP8 of REC A. The demodulated signal of REC B will appear on the scope in a figure 8. Short out the input to REC B by placing a test lead between TP1 and TP8 of REC B. A wavy no-signal line will now appear on the scope. Now ground and unground TP1 of REC B in rapid succession. Adjust CENTER FREQ control of REC B until the cross-over of the figure 8 coincides with the no-signal line on the scope.**
8					Repeat step 7 for REC A center frequency adjustment by removing the signal from CHAN B and shorting out at brief intervals the signal of REC A.**

TABLE VIII TELE-SIGNAL MODEL 102 TONE RECEIVER  
AND 110 COMPARATOR LINEUP (Continued)

Test Step No.	Purpose of Test	Measuring Equipment	Test Points	If Necessary Adjust	Requirement and Procedure
9	Bias adjustment	Same as step 7	2 and 8 of REC A	BIAS + of REC A	Apply signal to both 102 receivers and check that both meters read 100. Turn CHAN A LEVEL control on the comparator fully counter-clockwise. Adjust the zero bias distortion (single vertical line on scope).**
10	Bias adjustment	Same as step 7	2 and 8 of REC A	See procedures.	Advance CHAN A LEVEL control until the meter reads 100. Reduce CHAN B LEVEL control until CHAN B meter reads 50. The signal bias distortion should still be zero. If a small error should be observed, adjust CHAN A center frequency control for approximately 1/2 the bias error. Use the BIAS + control of REC A to correct for the remainder.**
11	Bias adjustment	Same as step 7	2 and 8 of REC A	See procedures.	Bring the level of CHAN B back to 100 and drop the level of CHAN A to 50. Observe the small error in bias and correct for it by a slight adjustment of REC B center frequency control.**
12	Bias adjustment	Same as step 7	2 and 8 of REC A	BIAS — of REC A	Place SENSE switch on the comparator to —. Repeat steps 9 through 11 adjusting BIAS — control of REC A.**
13	Operation				For operation, make sure both input signal levels are normal (and preferably equal), adjust the input level controls on the comparator until both meters read 100. Place the SENSE switch on the comparator to the desired sense.

\* The transistor switch circuit shown in Figure 3-12 can be used with an audio oscillator to key the 101 F/S tone transmitter with a 50/50 square wave, instead of using the 100A test distributor. (See Figure 3-12.)

\*\* Alignment procedure section of ME-701, *Tele-Signal Corporation Model 2000 F/S Tone Diversity System*.



**FIGURE 3-12. TRANSISTOR SWITCH  
(SQUARE WAVE GENERATOR)**

**NOTES:**

1. Connect a HP 130B scope to test points 2 and 7 of 101 F/S tone transmitter.
2. Connect the transistor switch to test points 2, 7, and 8 of 101 F/S tone transmitter.
3. Connect the 200CD audio oscillator as shown, set for 25 cycles, and adjust the output level of the audio oscillator until a 50/50 square wave signal appears on the scope.
4. The 101 F/S tone transmitter is now being keyed properly, and the 102 F/S tone receiver can be adjusted per Table VIII, steps 3 through 12.

**3.2.3.10 HF System Lineup (Figures 3-4 Through 3-6)**

Line up the HF radio transmitter on the operating frequency adjusted to full power output. For detailed tuning information, refer to HF transmitting section lineup (paragraphs 3.2.3.1 through 3.2.3.7) and Volumes I and II of ME-704 for transmitting set, radio, model GPT-10K. Tune the HF receiving system, DDR-6, to the operating frequency, and search for the transmitter signal. For detailed receiver tuning procedure, refer to HF receiving section lineup (paragraph 3.2.3.8) and the technical manual for receiving set, radio, model DDR-6.

At the transmitter location, patch the 1A telegraph test set to the transmitter series loop jack at the input of the order wire circuit tone transmitter. Set the 1A test set to transmit the test sentence (FOX) at zero bias. Measure the tone output of each 101 tone transmitter at each XMT KEYS OUT jack with a 400D VTVM terminated with a 600-ohm resistor. The reading should be -10 db. Patch the terminated VTVM in the PAD OUT jack and adjust the pad for -10 db. This is the level that feeds into the

GPT-10K transmitter. At the receiver location, patch the 28 KSR teletype to the order wire circuit tone receiver output. Patch a high impedance VTVM (HP 400D) into the AMP OUT MON NORMAL jack and adjust the audio gain control of the associated MSR-6 for a reading of -10 db. Next, adjust the diversity channel using the same procedure outlined above.

At the transmitter location, replace the 1A test set with the 28 KSR machine. Hand send a telegraph message.

Line up the data circuit using the associated multiplex equipment following the same procedure given above.

For detailed adjustment of the telegraph multiplex equipment, refer to the transmitting section lineup for adjustment of the 101 F/S tone transmitter and to the receiving section lineup for adjustment of the 102 F/S tone receiver and 110 comparator (Tables VII and VIII).

By selecting the four-wire (TR and REC) side of the Lynch teletype repeater, the 28 KSR (OW) teletypewriter can be used to make overall circuit checks with the distant terminal. The receive leg of the Lynch repeater (on 63C1 switchboard) may be patched to either data or OW circuits for testing.

If the signal is not received, meters can be plugged into various jacks to determine if the circuits are working properly. A dc milliammeter can be plugged into the transmitter series loop jack of the 101 tone transmitter input and the receiver series loop jacks of the 102 tone receiver output; 62.5 mls should be read at these jacks. A 400D VTVM terminated with a 600-ohm resistor patched into the XMT KEYS OUT jack of the 101 tone transmitter should read -10 db. The high impedance VTVM patched into the AMP OUT MON jacks should read -10 db.

**3.2.4 Frequency Assignments**

The tone frequencies and width of frequency shift used in the multiplexing systems at Kano, Zanzibar, Atlantic Ship, and Indian Ocean Ship sites are listed in Table IX.

Each HF radio link used for Project Mercury will require the use of several frequencies to permit operation at all hours and all periods of the year. Table X is a listing of frequencies which should be desirable for each link. This

TABLE IX  
TONE MULTIPLEXING FREQUENCIES

<i>Kano</i>			<i>Zanzibar</i>		
	From London	To London		From Kano	To Kano
CCT No. 1	1530 cps*	1530 cps*	CCT No. 1	1445 cps**	1445 cps**
No. 2	1190	1190	No. 2	1275	1275
No. 3	850	850		From Indian Ocean Ship	To Indian Ocean Ship
			No. 1	595**	595**
					1275
	From Zanzibar	To Zanzibar	Intrasite		
CCT No. 1	1445 cps**	1445 cps**		1615 cps**	1615 cps**
No. 2	1275	1275		1445	1445
				1275	1275
				1105	1105
<i>Indian Ocean Ship</i>			<i>Atlantic Ship</i>		
	From Perth	To Perth		From NY	To NY
CCT No. 1	765 cps**	765 cps**	CCT No. 1	765 cps**	765 cps**
	1785			1785	
No. 2	935	935 cps**	No. 2	935	935
	1955***			1955***	
	From Zanzibar	To Zanzibar		From Canary	To Canary
CCT No. 1	595**	595**	CCT No. 1	595 cps**	1105 cps**
	1445			1445	
			No. 2	765	
				1615***	1275

\* Frequency shift of  $\pm 85.0$  cps

\*\* Frequency shift of  $\pm 42.5$  cps

\*\*\* Two frequencies assigned per CCT—quadruple diversity

frequency assignment is based on National Bureau of Standards calculations. To prevent interference, a separation of 10 per cent between the transmit and receive path frequencies will be required. Selection of the exact frequencies is a complex matter and early surveys and operation tests at each site are planned to ensure the highest degree of performance.

The use of the existing NBS Radio Propagation Prediction Service, as applied to the Mercury communications system, is proposed. NBS Radio Propagation Prediction Service forecasts have shown a high degree of accuracy. Short term forecasts are issued 1 hour in advance for a 6-hour period and give a computed quality figure for the transmission path.

### 3.2.5 Miscellaneous Operating Information

The operation procedures for each remote site during periods of the orbital mission are covered in MO-101R, *Remote Site Operations Procedures*.

During periods of normal operation, the HF point-to-point radio equipment will require a minimum of adjustment except at times of frequency change. Mercury traffic carried on circuits furnished by this system will be controlled at the site control area. Routine operating procedure in the equipment area will include:

a. *Maintenance of Logs*—See MG-102 and MO-101R. Forms MP-205A, B, and C are shown in Figures 3-13, 3-14, and 3-15.

b. *Frequency Checks*—0.005-per cent frequency tolerance.

c. *Wave Analysis*—Distortion checks.

d. *Order Wire Operation*—Lineup, test, and maintenance.

The necessary frequency changes (QSY) will be governed by propagation predictions, circuit conditions, and premission operational directives.

Section 7 on log records of MG-102, *Plant Operating and Maintenance Procedures*, explains the purposes of log records, where they are provided and the format to be used. This section also lists the responsibility for the maintenance of log records. The meter indications, circuit merit figures, and equipment in use (by hours) must be recorded as required for future reference.

### 3.2.6 Patching and Switching Arrangements

The interconnection of radio and tone multiplexing equipment facilitates the patching of spare equipment into service with a minimum of lost time and effort in the event of equipment failure. Operating frequencies and channels can easily

TABLE X  
FREQUENCIES REQUIRED FOR HF RADIO CIRCUITS

<i>Path</i>		<i>Frequencies (MC)</i>
New York	Atlantic Ship	9, 12, 15.5, 20
Atlantic Ship	Grand Canary Island	7, 9.5, 13, 18
London	Kano	8.5, 12.7, 16, 22.5
Kano	Zanzibar	12.5, 15, 18, 21.5
Zanzibar	Indian Ocean Ship	8, 11, 15.5, 22
Indian Ocean Ship	Perth	8, 11, 15, 20

MP-205A (8-6C)

# RADIO COMMUNICATION LOG TRANSMITTING STATION DAILY LOG RECORD

TIME GMT	CALL LETTERS	FREQUENCY IN KC	CHECK OF DEV. IN KC	ORA MADE	EMISSION	ANTENNA SYSTEM USED	POWER		ACTION TAKEN AND REMARKS	OPERATOR SINE		HOURLY TRANS. IDENT.	
							ON	OFF		RAD	OTHER OFFICE	G.M.T.	OPR. SINE
												0000	
												0100	
												0200	
												0300	
												0400	
												0500	
												0600	
												0700	
												0800	
												0900	
												1000	
												1100	
												1200	
												1300	
												1400	
												1500	
												1600	
												1700	
												1800	
												1900	
												2000	
DATE	GMT	SHEET	SYSTEM	TRANSMITTER		POWER AMPLIFIER		SITE					
				TYPE	SERIAL	SERIAL	TYPE						
								2100					
								2200					
								2300					

SAMPLE

FIGURE 3-13. COMMUNICATIONS LOG MP-205A



MP-205-C (B-60)

# RADIO COMMUNICATIONS LOG RECEIVING STATION DAILY LOG RECORD

R. SYSTEM \_\_\_\_\_  
R. CIRCUIT \_\_\_\_\_  
TYPE OF RECEIVER \_\_\_\_\_

SITE \_\_\_\_\_  
DATE (GMT) \_\_\_\_\_  
SHEET NO. \_\_\_\_\_

[illegible]

**FIGURE 3-15. COMMUNICATIONS LOG MP-205C**

be changed by means of the spare equipment and patch jacks. Jacks also provide a means of testing individual units of the system.

Figure 3-16 shows a typical jack arrangement for the receiving system at a land site. The regular receiving channel from antenna to teletype equipment is arranged through normal (closed) contacts of jacks. Some patch cords are needed for normal service. Should equipment substitution become necessary, due to equipment failure or for maintenance reasons, additional patch cords can be used to place spare equipment in service.

The coax rf patch assembly, QDP-38, is used between the receiving antenna and the diversity receiver input. Table IX is an example of patching procedure used when an antenna multicoupler develops trouble.

Insert one plug of a patch cord into the ANT jack and the other plug into the REC IN jack. This operation eliminates two patch cords and connects the antenna directly to the diversity receiver. The patch cord for the jackfield is a length of RG-8/U coaxial cable fitted at each end with a special quick-disconnect plug, type QDS. The circuit from the diversity receiver output to the F/S tone receiver input is connected through an audio jackfield, type CPP-4C. Monitor jacks are provided here so that a high impedance monitor, such as a vacuum-tube voltmeter, can be connected to the line without opening the normal-through connections. Patch cords for these jacks are either two or three conductors fitted at each end with the proper plug to fit the jacks. Patching can be done here at the tone or audio level. Should the regular diversity receiver become inoperable, a patch cord plug could be inserted into the spare diversity receiver output marked EQPT (not shown in Figure 3-16). The other plug must then be inserted in the regular LINE jack. This connects the tone output of the spare diversity receiver (tuned to the operating frequency) to the input of the isolation transformer and on to the F/S tone receivers. The dc output from the F/S tone receiver is connected to the teletype printer through loop REC CONV OUT and DC LINE IN jacks. The loop jack is used to connect a milliammeter

in series with the line to measure the loop current. Patching can be done at the REC CONV OUT and DC LINE IN jacks to patch the spare printer in service if the regular printer develops trouble. A patch from the regular REC CONV OUT jack to the DC LINE IN jack of the spare printer will place the spare printer on the line.

Figure 3-17 shows a typical jack arrangement for the transmitting system at a land site. This is similar to the normal-through jacks of the receiving system described above. This system also uses coax patch jacks. The transmitting coax patch jacks do not have normal-through connections. Instead, the antenna and transmitter output are each brought out to the coaxial jack. A coaxial patch cord must be inserted in these two jacks to complete the circuit. The teletypewriter sending loop is connected to the F/S tone transmitter through the DC LINE OUT, TRANS KEYER IN, and TRANS SERIES LOOP jacks. The line normals through these jacks. A milliammeter can be inserted in the loop jack to measure the sending loop current. Patching a spare teletypewriter on the line is done at the DC LINE OUT and TRANS KEYER IN jacks as described in the receiving system. The F/S tone transmitter output is connected to the SSB transmitter input through the normal-through audio jacks. Monitor jacks are provided with the audio jacks. A high impedance vacuum-tube voltmeter can be plugged into the MON jack without opening the circuit. Two information input channels are brought out to jacks designated CHAN 1 IN and CHAN 2 IN. The teletype lineup is on normal-through jacks to CHAN 1 IN. Should channel 2 operation be desired, a patch will be necessary; connect a patch from the LINE jack to CHAN 2 IN. A safety interlock feature of the coax patch jacks prevents the transmitter from being turned on unless an antenna is connected to the transmitter.

### 3.2.7 Monitoring Facilities (Figure 3-18)

The radio system contains a great number of monitoring devices and indicators. These include such items as lamps, panel meters, and jacks for plug-in meters associated with the individual units of the system. Generally, each

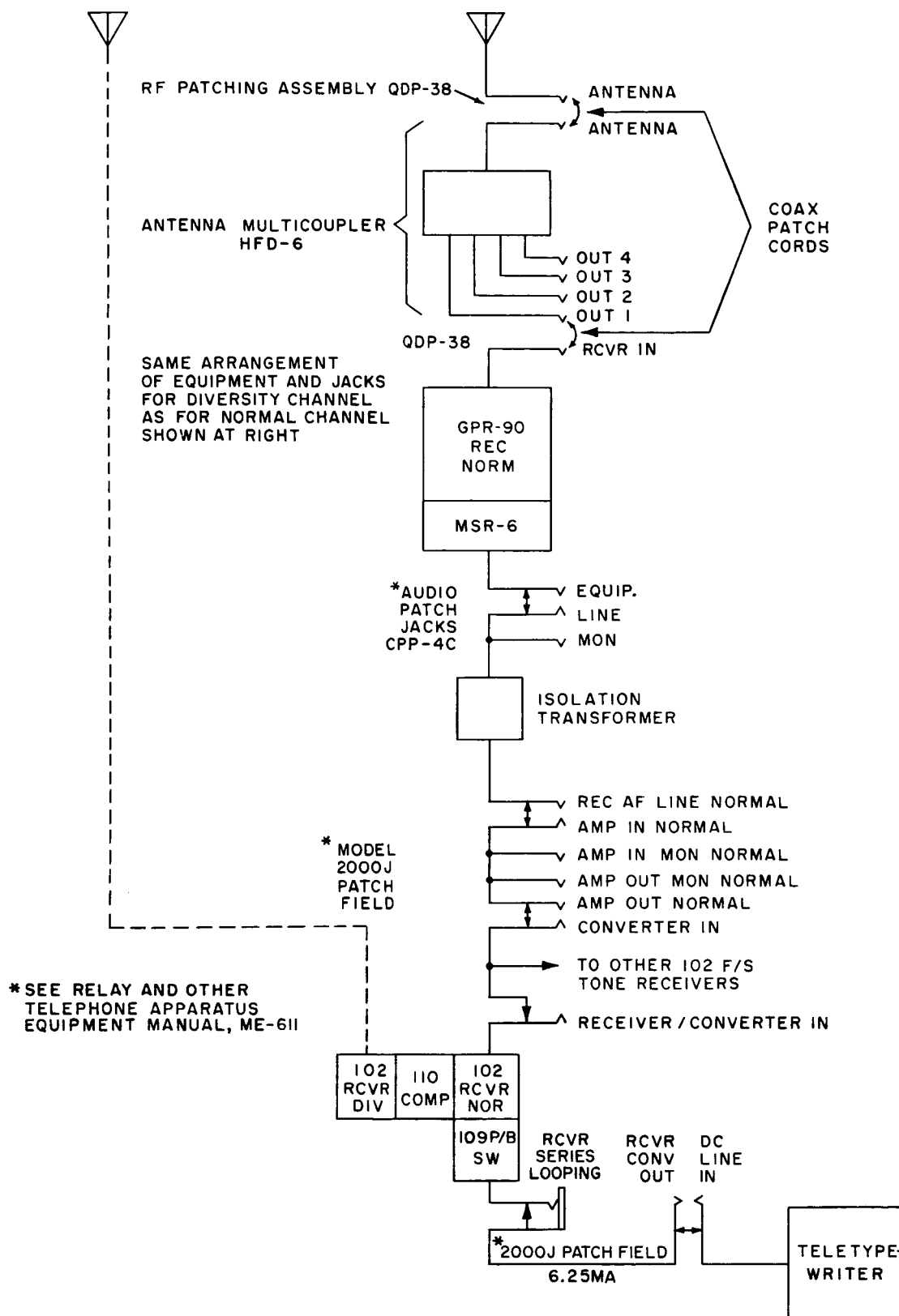


FIGURE 3-16. TYPICAL JACK ARRANGEMENT FOR RECEIVING SYSTEM, LAND SITES

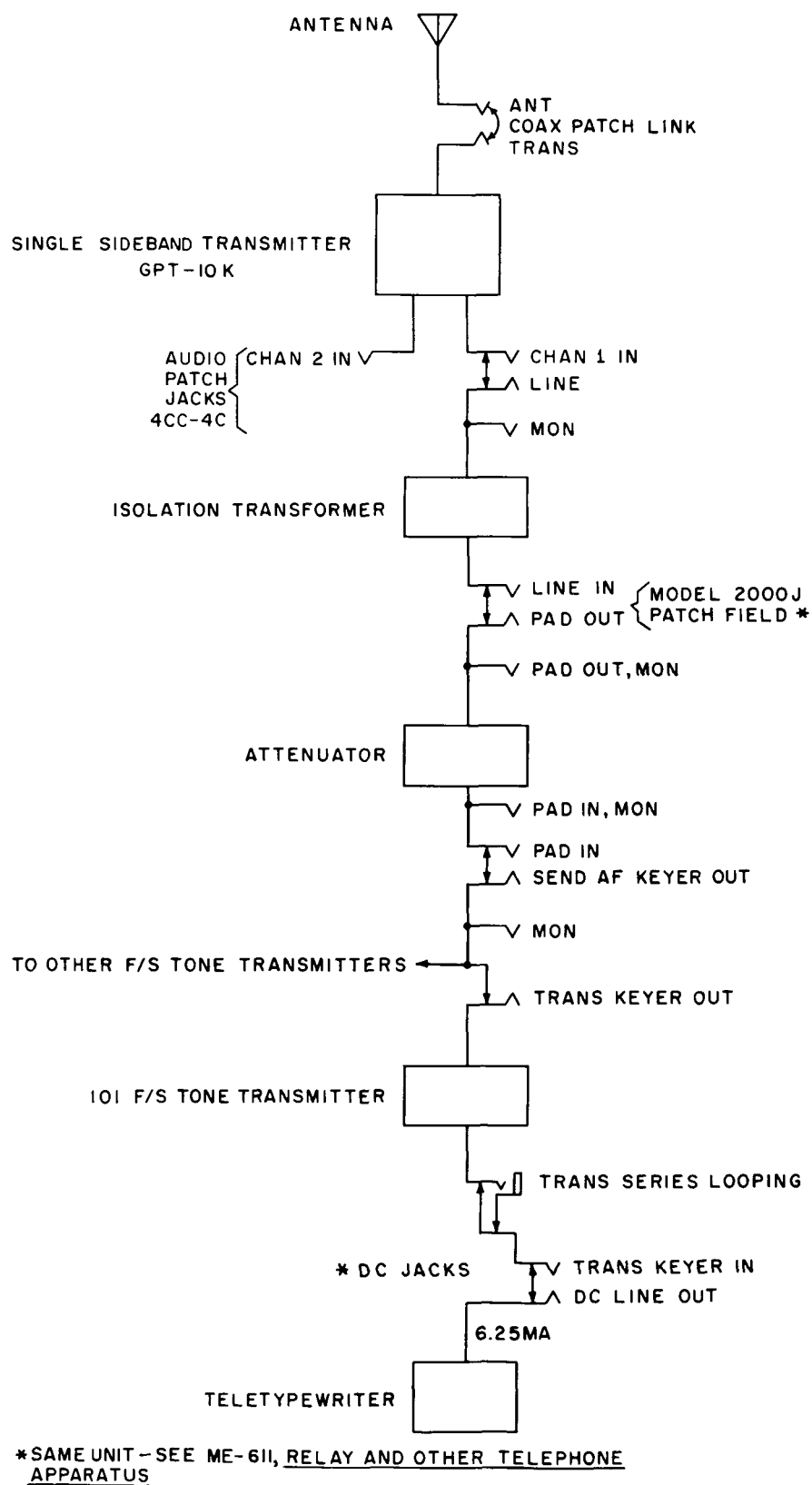


FIGURE 3-17. TYPICAL JACK ARRANGEMENT FOR TRANSMITTING SYSTEM, LAND SITES

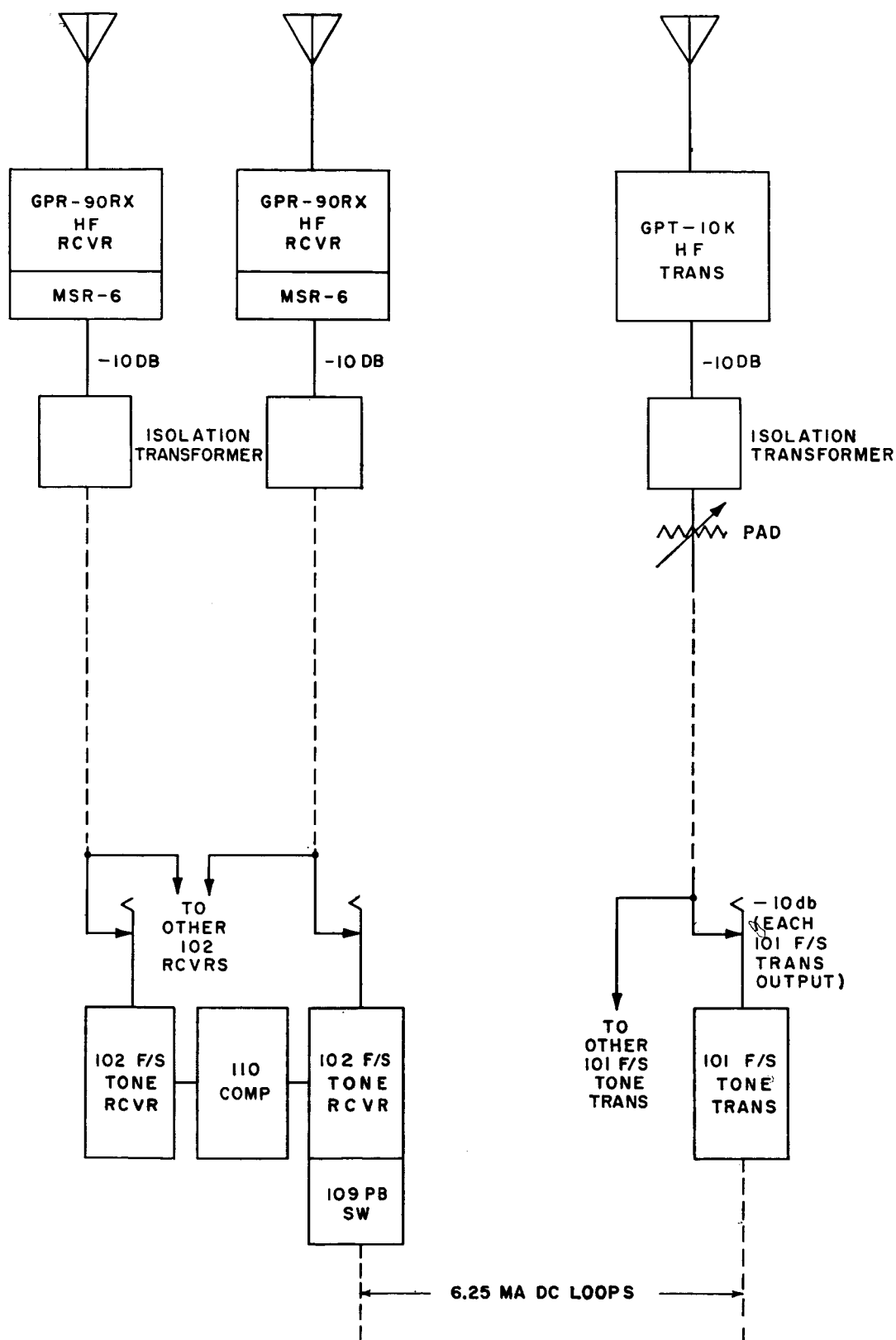


FIGURE 3-18. SYSTEM LEVEL DIAGRAM

unit has its own indicator to tell when the primary source of power is applied. The jack-fields, described in paragraph 3.2.6 explain the use of the monitor and loop jacks as an aid to system monitoring and operation. Provisions

are made to monitor teletype circuits by patching in a monitor machine.

Table XI lists the various units, the monitoring indicators, and their functions.

**TABLE XI**  
**MONITORING FACILITIES**

<i>Unit</i>	<i>Indicator</i>	<i>Function</i>
Receiver, GPR-90 RXD	S meter	Indicates received signal strength.
	Phone jack	Plugs in head phones to monitor audio output.
Oscillator, VOX-3	Panel meter	Reads HFO output, BFO output, VM output, or VFD output depending on setting of meter selector switch.
	ZERO BEAT lamp	ZERO BEAT lamp for calibration, and also for setting dial on frequency.
	INNER OVEN lamp	Lights when power is on inner crystal oven.
	OUTER OVEN lamp	Lights when power is on outer crystal oven.
Mode Selector Receiving, MSR-6	L lamp	Indicates reception is on the lower side-band.
	U lamp	Indicates reception is on the upper side-band.
AFC Unit	CAR LEVEL meter	Indicates level of 17 kc in MSR-6.
	Drift meter	Indicates a correction voltage delivered to MSR-6.
	FADE ALARM lamp	Indicates loss of carrier below a level where the AFC unit no longer controls.
LSP-7 Loud Speaker Panel	Loud speaker	Aural monitoring of diversity receiver output.
F/S Tone Receiver, Model 102	Front panel test jacks	To insert scope or voltmeter to check cardinal circuit points, such as input tone demodulated square wave and voltages.

TABLE XI MONITORING FACILITIES (Continued)

<i>Unit</i>	<i>Indicator</i>	<i>Function</i>
Dual Diversity Comparator, Model 110	Two panel meters	Visual level indicator of the tone levels of the normal channel and the diversity channel.
	Front panel test jacks	To insert scope to observe differential rectifier output or the diversity switch signal.
F/S Tone Transmitter, Model 101	Front panel test jacks	To plug in a scope or voltmeter for monitoring and alignment of the various circuit components.
Mode Selector Transmitting, SBE-3	Panel meter	Indicates USB audio level LSB audio level, total of both sidebands and carrier, RF level of both sidebands and carrier depending on position of meter selector switch.
	EXCITER lamp	Glow during operation when EXCITER switch is ON and exciter is activated by VOX.
	OVEN lamp	Glow when thermostats demand oven heating.
Sideband Level Monitor, SLM	Panel meters	Indicate levels in the upper sideband and the lower sideband filter outputs of the SBE unit.
Spectrum Analyzer	Oscilloscope	Used to monitor 3 major RF test points: SBE output, IPA output, and PA output.
		Measures odd order distortion in the SSB transmitter.
Transmitter GPT10K	Panel meters	Various meters to indicate such readings as filament voltage, plate and screen current, and voltage and RF output.

### 3.2.8 Emergency Operation Procedure

Spare HF transmitters, diversity receivers, and tone multiplex equipment are provided. This equipment will be energized and can be made ready for operation in one of two different methods. It can be tuned to the operating fre-

quency and work in parallel with the regular equipment. Should the regular DDR-6 receiver fail, the tone output of the spare DDR-6 receiver can be patched to the group input of the regular tone receivers. If the regular SSB transmitter fails, the spare transmitter (pretuned to the operating frequency and patched to the spare

transmitting antenna at the coaxial patch jacks) can be made operational by applying plate voltage. The group output from the tone transmitters must then be patched into the spare transmitter input. The other method would be to operate the spare radio equipment on a different frequency in case the operating frequency fades out. This would require coordination with the distant terminal of the HF radio circuit. Patching of the tone transmitters and tone receivers to the spare radio equipment would be performed the same as in the other method where the spare radio equipment is tuned to the operating frequency.

AC power failure is not expected to be a serious problem since stand-by diesel generators will be provided. These stand-by generators will supply power to the ac mains in case of failure of the regular diesel generators. This procedure will be outlined in the power systems manual.

If the transmitter output filter should develop trouble, the filter shorting unit, model HFF-DS, can be plugged in to permit operation without an output filter. If the exciter filter develops trouble, it can be patched out to permit operation without the exciter filter.

## SECTION 4. MAINTENANCE

### 4.1 GENERAL INFORMATION

Most of the units of equipment in the HF radio system are designed for long term and trouble-free life. Proper fusing offers protection for all sections of the various units. The primary power, the B+ (hv) and the oven (temperature controlled) heater circuits are fused. Fuse replacement, pilot lamp replacement, and tube replacement will be required. The receivers will require alignment only if indicated by fault investigation. The GPT10K transmitter will require the most preventive and corrective maintenance work. The moving parts will require replacement at times if the duty cycle is high. These parts will be replaced on an assembly basis in most cases. The transmitter also requires continuous observation and operator's maintenance. The spectrum analyzer FSA serves to monitor several critical RF points, and numerous meters and lamps are built into the unit for further circuit observations. The operator's maintenance includes keeping a record of meter readings as well as an events log containing information pertinent to the transmitter operation history. The monitoring and key maintenance is covered in Section 3 of this manual. Tests on the HF filters are covered in ME-702, *HF Filters*.

#### 4.1.1 Receiver Sensitivity Measurement

Step	Operation
1	Connect 606A signal generator to antenna jack of receiver. Set signal generator to operating frequency modulated 30 per cent with 1 kc.
2	Set all RF and audio controls of receiver and MSR to maximum.
3	Patch 600-ohm VU meter into LINE OUT jack (MSR audio output).

- 4 Adjust signal generator for 0.5-micro-volt output. Read VU meter in LINE OUT jack.
- 5 Turn signal generator off.
- 6 Noise level as read on the VU meter should be at least 20 db less than the reading in step 4.

#### 4.1.2 Distortion Observation, FSA

Tuning/loading adjustments to meet distortion requirements are as follows:

- a. Adjust transmitter's output per step 7 of paragraph 3.2.3.6, and analyzer's picture per step 5 of paragraph 3.2.3.7.
- b. Observe distortion on spectrum analyzer. Signal/distortion must meet requirement of 35 db.

#### NOTE

At this point, the transmitter should have previously been tuned/loaded on carrier (paragraph 3.2.3.5); if it has not been retuned/reloaded for SSB carrier-suppressed emission (paragraph 3.2.3.6), its tuning/loading controls may require slight adjustments for SSB emission and the distortion may be too great (paragraph 3.2.3.7). The first step to take is to retune/reload the transmitter for SSB emission in line with procedures as set forth in paragraph 3.2.3.6. As each stage is retuned, and/or reloaded, note the effect on the signal distortion and compromise between optimum tuning/loading and signal distortion. For example,

unloading the IPA slightly may decrease distortion appreciably. A small amount of detuning in the PA stage may decrease distortion considerably without seriously affecting the transmitter's output. Likewise, a small amount of unloading or overloading in the PA stage may improve the general situation. The SBE's drive should be kept as low as possible below the limiting values stated in paragraph 3.2.3.6. Experience in tuning/loading transmitters will enable the operator to make the most effective minor adjustments quickly, being guided by meter readings and results expected by increasing/decreasing a reading on any specific meter.

c. Turn CARRIER INSERT switch on SBE's panel clockwise from position 0 until analyzer shows required amount of carrier power. In practice, SSB transmitters are generally operated with -10-db or -20-db carrier insertion to facilitate receiver operation.

The sideband level monitor model SLM has two VTVM's that monitor the sideband levels at the 250-kc point in the SBE-3. Its primary purpose is to guard against excessive distortion arising within the SBE's 250-kc balanced modulator unit. The SBE unit has a db meter that monitors the sideband levels at the AUDIO input point. This is done via the METER SW selector. It should be pointed out that the AUDIO and 250-kc sideband levels differ slightly. The difference is of little practical importance and, to minimize confusion among operators, is zeroed by adjusting the SLM's potentiometers to make the SBE and SLM levels read alike.

#### 4.1.3 Transmitter Frequency Measurement

The expected frequency tolerance for Mercury point-to-point circuits is  $\pm .005$  per cent of the assigned frequency.

##### 4.1.3.1 *Frequency Measurement, 10 Cps—10.1 MC*

Proceed with the following procedural steps for transmitter frequency measurement, referring to Figure 4-1:

1. Plug in model 525A. Be sure counter power switch is off whenever plug-in units are changed.
2. Set FUNCTION SELECTOR to FREQUENCY.
3. Set FREQUENCY UNIT switch to desired gate time.
4. Set DISPLAY TIME control to desired display time (usually minimum).
5. Connect signal to SIGNAL INPUT connector.
6. Set MIXING FREQUENCY switch to 0.
7. Adjust GAIN control until tuning eye closes but does not overlap.
8. Read frequency.

##### 4.1.3.2 *Frequency Measurement, 10.1 MC—100 MC*

Proceed as follows, referring to Figure 4-2:

1. Plug in model 525A. Be sure counter power switch is off whenever plug-in units are changed.
2. Set FUNCTION SELECTOR to FREQUENCY.
3. Set FREQUENCY UNIT switch to desired gate time.
4. Set DISPLAY TIME control to desired display time (usually minimum).
5. Connect signal to SIGNAL INPUT connector.
6. Set MIXING FREQUENCY switch to TUNE.

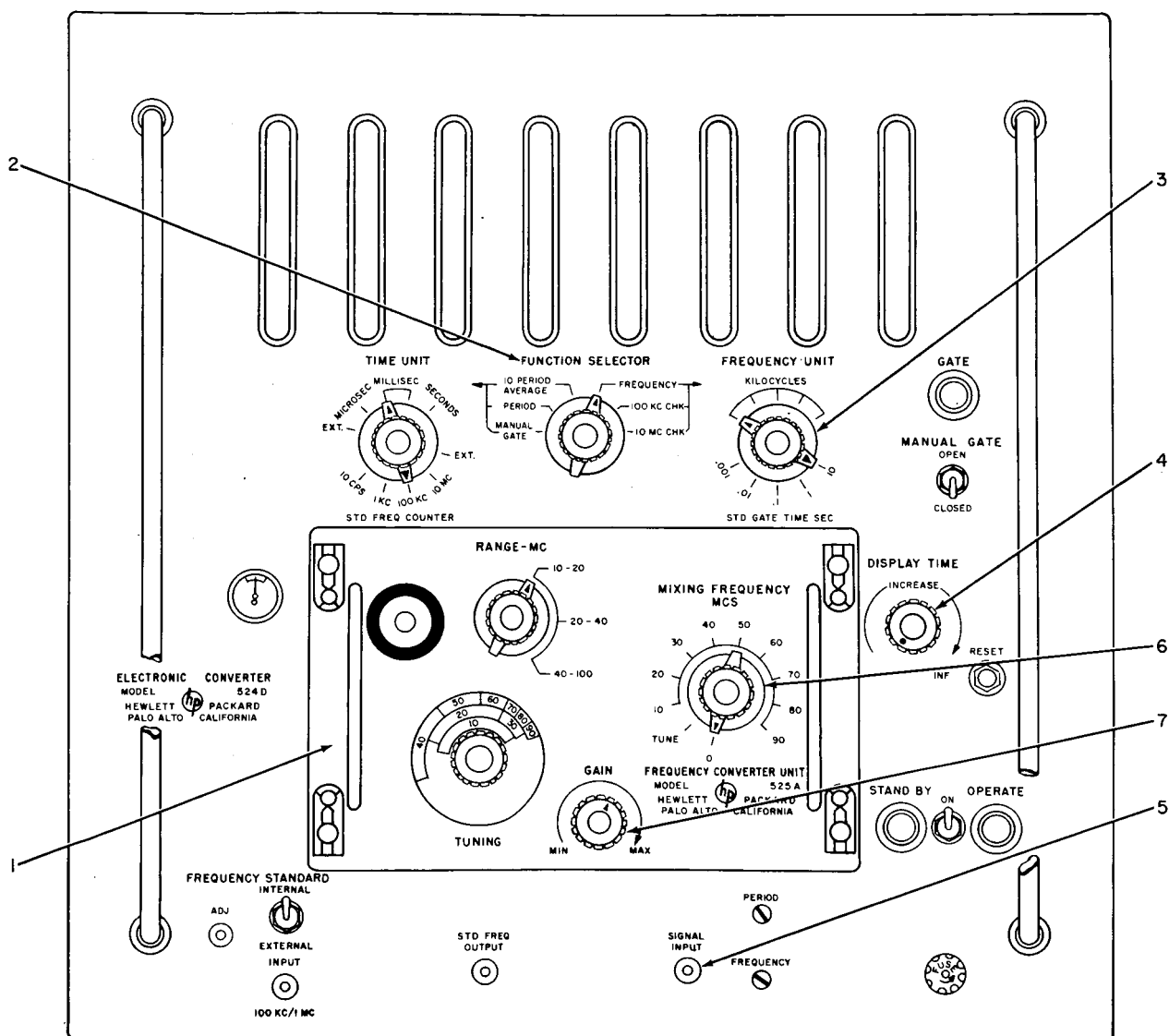


FIGURE 4-1. HP 525A FREQUENCY COUNTER, OPERATING METHODS FOR FREQUENCY MEASUREMENTS BETWEEN 10 CPS AND 10.1 MC

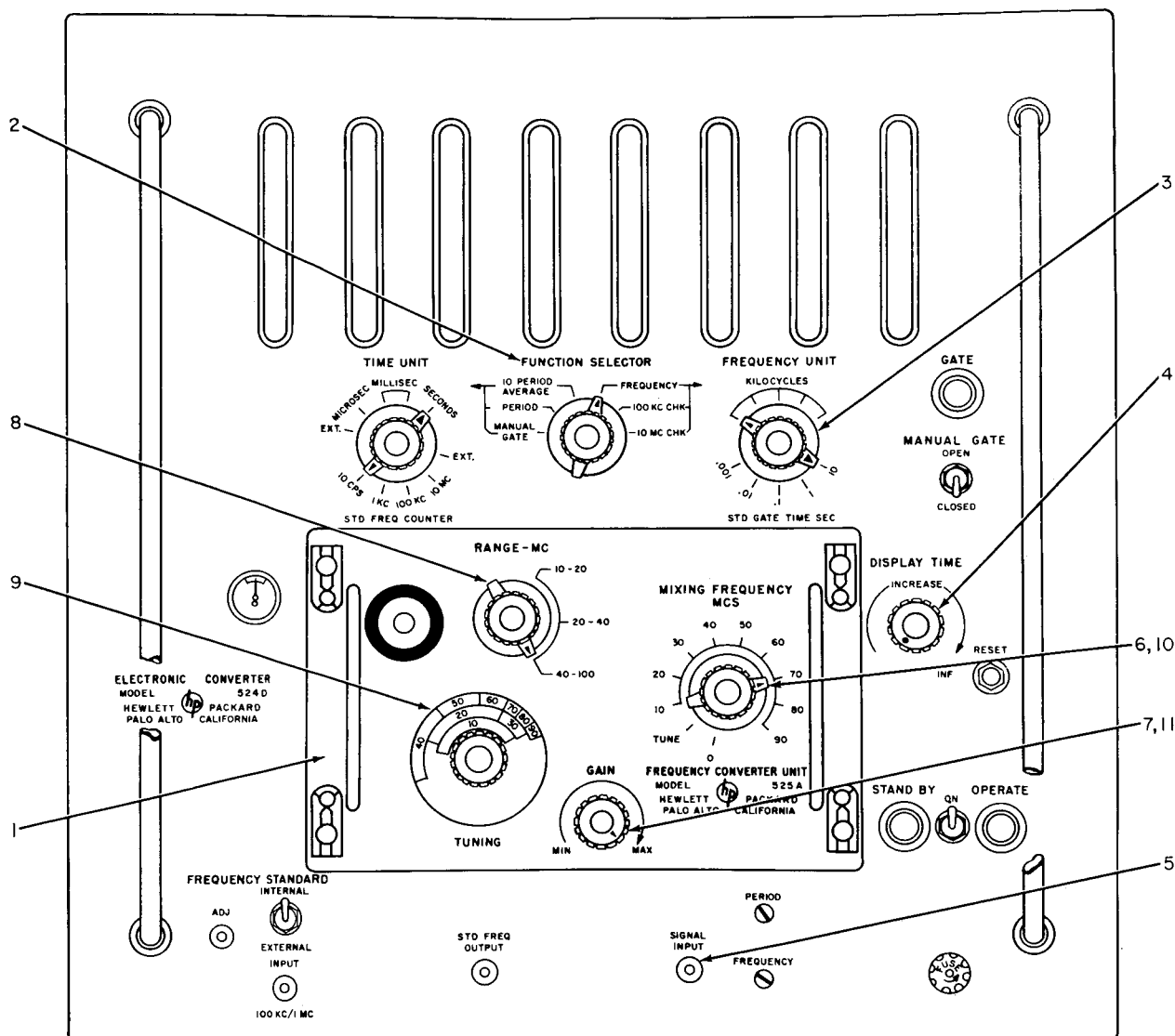


FIGURE 4-2. HP 525A FREQUENCY COUNTER, OPERATING METHODS FOR FREQUENCY MEASUREMENTS BETWEEN 10.1 MC AND 100 MC

7. Set GAIN control to maximum clockwise position.
8. Set RANGE-MC switch to 10-20 position. (Starting on lowest range avoids harmonics. If frequency is approximately known, set RANGE-MC switch to range which includes frequency.)
9. Set TUNING control to left end of 10 region. Adjust TUNING control to obtain minimum shadow on tuning eye, changing RANGE-MC switch as necessary. If eye overlaps, reduce GAIN control setting and retune TUNING control.
10. Set MIXING FREQUENCY switch to the frequency indicated by TUNING dial.
11. Adjust GAIN control until tuning eye closes but does not overlap.
12. Read frequency by adding the mixing frequency (mc) and reading on the counter (kilocycles). If reading on counter is less than 100 kilocycles, set MIXING FRE-

QUENCY control to next lower mixing frequency and make another measurement.

#### 4.1.4 Station Guardian—VSWR Measurements

The M.C. Jones micromatch coupler and SG-33 station guardian equipment protects the

transmitter and antenna system from damage caused by abnormal conditions and allows forward power and VSWR measurements. If load condition or RF output change sufficiently, an alarm will be actuated and the transmitter power will be reduced or turned off. A switchable meter provides for direct reading power measurements.

##### 4.1.4.1 Calibration of SG-33

<i>Step</i>	<i>Designation</i>	<i>Operation</i>
1	Power ON/OFF	ON
2	INDICATOR SELECTOR switch	FOR
3	Reduce transmitter power to minimum allowable level.	(Power alarm adjustment)
4	Power level adjustment	Adjust until green light is extinguished.
5	Reverse position of micromatch coupler in transmitter line.	(VSWR alarm adjustment)
6	INDICATOR SELECTOR switch	Back
7	Increase transmitter power to level at which warning is desired.	
8	VSWR level adjustment	Adjust until red light comes on.
9	Restore micromatch coupler to normal position in transmitter line	

##### 4.1.4.2 Measurements

<i>Step</i>	<i>Designation</i>	<i>Operation</i>
1	INDICATOR SELECTOR switch	FOR Read RF Pwr (Watts)
2	INDICATOR SELECTOR switch	CAL
3	SWR calibrate	Set for full scale reading
4	INDICATOR SELECTOR switch	SWR  Read SWR directly on meter

Section 21 of MG-102, *Plant Operating and Maintenance Procedures* entitled Maintenance Program outlines the procedures and associated forms to be used in maintenance. The section is intended to assist in attaining the desired level of performance of the equipment.

## 4.2 PREVENTIVE MAINTENANCE

### 4.2.1 General Information

The preventive maintenance effort should include tube tests, ac/dc voltage measurements, and inspection of equipment. The tubes should be within the manufacturer's tolerance, which is usually 20 per cent of the tube manual value. The equipment manuals list (in chart form) the ac/dc voltages for the individual units.

The preventive maintenance program should include the inspection and checks necessary to determine the causes of fuse failure, resistor overload, and component failure. The inspections should also include the removal of dust, the correction of dampness, charring, loose parts, contact wear, and corrosion.

### 4.2.2 Schedules

Section 21 of MG-102, *Plant Operating and Maintenance Procedures*, entitled Master Maintenance Schedules provides the information required to implement the maintenance program. It lists all the routines except daily assignments. Operating checks made daily and weekly are covered in Section 13 of the manual.

The equipment manuals associated with the HF radio equipment and tone equipment also list maintenance periods that should be observed. Table XII summarizes the maintenance items and should be supplemented by the information contained in the equipment manuals and the plant operating and maintenance procedures manual.

## 4.3 TROUBLESHOOTING

### 4.3.1 General Information

When an equipment unit failure occurs, the power circuits should be checked first. Pilot

or indicator lamps provide a visual indication of the presence or absence of line voltage. Some equipment operates directly from the ac line voltage. An example is the indicator on the SBE-3 sideband switching relay.

Noise may be an indication of trouble. In the receiver area, this noise may often be due to contact operation or faulty teletypewriter equipment operation. Filters on the Lynch (72-4) repeaters and 28 KSR sending contacts should be checked. It may also be necessary to check that there is a ground on the metal cover of the 28 KSR line relay.

If the actual cause of trouble is not obvious, a fuse and tube check should be made along with a visual inspection.

### 4.3.2 Procedures

The manufacturer's equipment manuals, for the various equipments, list troubleshooting procedures for the more complex units.

The manual covering the variable frequency oscillator, VOX, covers troubleshooting procedures. Trouble-shooting procedures for the transmitting mode selector, SBE-3, are listed in the manual. Section V of the TMC manual for the GPT10K transmitter is devoted entirely to troubleshooting procedures. This section includes photo breakdowns, voltage and resistance tables and test points, as well as procedures based on operation and analysis charts.

## 4.4 CORRECTIVE MAINTENANCE

Most of the units in the receiving system, however, are not complex in nature and do not require detailed corrective or repair procedures. The transmitting mode selector, SBE-3, equipment manual, paragraph 4.4, page 4-1 to 4-4, covers the corrective maintenance items as well as adjustments and alignment.

The TMC transmitter, GPT10K, has many more moving parts which may require replacement at times. Some of the parts are as follows:

- a. Band and load switches
- b. Blowers

TABLE XII  
MAINTENANCE SCHEDULE

<i>Equipment Status</i>	<i>Frequency</i>	<i>Routine</i>
In use	Once per shift	Check equipment record. Make minor readjustments. Observe and record metered indications.
Shut down	Daily	Inspect parts for heat damage, wear, dust, etc.
	Monthly	Recondition rotary and switch contacts as required. Remove dust. Replace dust filters. Inspect gear trains and lubricate if required.
	Semiannual	Complete inspection for dirt, dampness, charring, loose parts, contact wear, and corrosion.
	Annual	Complete lubrication of gear trains and rotary equipment.

c. Contactors, shorting and interlock switches, relays.

These parts are usually replaced on an entire assembly basis. The GPT10K equipment manual also includes an operator's check-off list (Table 6-1) which indicates checks to be made, how to make the checks, and precautions

to be observed. The maintenance data for the relays associated with the GPT10K transmitter is listed in Table 6-2 of the equipment manual.

#### 4.5 SPECIAL TOOL AND MATERIAL LIST

A special tool and material list follows:

<i>Equipment Unit</i>	<i>Tool or Material</i>
a. MSR-6 (Mode Selector)	DC source (0 to $\pm 10$ volts)
b. GPR-90RX (Receiver)	Nonmetallic alignment tool, 600-ohm load headphones.

<i>Equipment Unit</i>	<i>Tool or Material</i>
c. VOX (Variable Oscillator)	Test cable assemblies CA108 through CA110 (and assorted coaxial fitting for test connections in general)
d. SBE-3 (Mode Selector)	Lubricant (light)
e. GPT10K (Transmitter)	Crocus cloth. Light oil lubricant spray can (oil) Large screwdriver (8 inches or larger) Hook-up wire (for modification and repair)

#### 4.6 TEST EQUIPMENT LIST

Table XIII lists the test equipment needed for installation, operation, and maintenance of transmitting, receiving, and antenna systems, and associated components.

#### 4.7 PARTS LIST—SPECIAL PARTS NOT LISTED IN EQUIPMENT MANUALS

Special parts not listed in equipment manuals are as follows:

- a. Detector crystals—Jones power meter.
- b. Zener diodes.

c. Headphones, E/W single cord—transmitter and receiver area; E/W double cord—transmitter and receiver area.

d. Extension cord, E/W tele-signal plug and jack—Tele-signal F/S tone equipment (for making test with equipment out of rack).

e. Extension cord, 110-volt, 3-wire, E/W 4 outlets—general use.

f. Test cord kit, E/W 1—double banana to BNC connector—HP test equipment; 1—double banana to tip connector; 1—double banana to double banana connector; 1—double banana to alligator clip connector.

TABLE XIII  
TEST EQUIPMENT LIST

<i>Test Equipment</i>	<i>Purpose</i>	<i>Required</i>
1. VHF Admittance Bridge Model B801	To measure impedance of transmission lines, baluns, dissipators, and antenna systems.	For the installation and maintenance of antenna systems and associated components.
2. RF Detector, GPR-90 Communications Receiver	To function as an RF detector for the RF bridge, above.	For the installation and maintenance of antenna systems and associated components.
3. Electronic Counter, Hewlett-Packard Model 524C Counter and 525A Converter	To accurately measure transmitted frequency and subcarrier multiplexing frequencies at HF transmitter location.	For installation, maintenance, and operation of transmitting equipment and to comply with frequency measuring requirements.
4. Electronic Counter, Hewlett-Packard Model 521C	To measure the frequency of the multiplexing equipment.	For the installation and maintenance of multiplexing equipment.
5. Volt-Ohmmeter, Triplet Model 630	To measure ac/dc voltage, resistance, and current of various components associated with all HF radio equipment.	For the installation, operation, and maintenance of all HF equipment.
6. VTVM, Hewlett-Packard Model 410B	To measure critical ac/dc voltages and resistances on HF radio components.	For installation and maintenance on critical circuits.
7. VTVM, Hewlett-Packard Model 400D	To measure intrasite transmission losses and critical low level ac voltages, to set audio and subcarrier levels.	For the installation, operation, and maintenance of receiving and multiplexing equipment.
8. Audio Oscillator, Hewlett-Packard Model 200CD	To generate audio frequencies in connection with response measurements and adjustments of various components.	For the installation and maintenance of transmitting, receiving, and multiplexing equipment.
9. RF Signal Generator, Hewlett-Packard Model 606A	To generate RF frequencies in connection with antenna impedance measurements, receiver and transmitter adjustments.	For the installation and maintenance of transmitting, receiving, and antenna components.

TABLE XIII TEST EQUIPMENT LIST (Continued)

<i>Test Equipment</i>	<i>Purpose</i>	<i>Required</i>
10. Oscilloscope, Hewlett-Packard Model 130B	To measure and observe critical ac voltage and waveforms on various electronic components.	For the installation and maintenance of transmitting, receiving, and multiplexing equipment.
11. Panoramic Panalyzer, Model SB-12a	To permit panoramic observation of received frequencies present at the IF amplifier of the HF radio-ground communication SSB diversity receiver (a similar spectrum analyzer is also furnished as a built-in feature of the GPT10K radio transmitter to monitor RF test points).	For operation and maintenance of the SSB receiving equipment. It will also be available to assist in interference studies and band surveillance.
12. Tube Tester, Triplett Model 3444	Trouble locating and routine testing of various transmitting and receiving vacuum tubes.	For maintenance of electronic equipment.

## SECTION 5. DRAWING INFORMATION

### 5.1 GENERAL INFORMATION

There are two general classifications of site drawings: job drawings and standard drawings. Job drawings are made for each site. Standard drawings cover units of standard equipment installed at any site.

Job drawings include an index of all site job drawings, site floor plans, relay rack or front equipment drawing, wiring lists, and application and interconnection drawings.

All job drawings for a particular site have the same base number. The base number for Kano, for example, is T-6G05. T-6G identifies it as a part of Project Mercury. The last two digits of the base number identify the site. The last 2, 3, or 4 digits following the base number indicate the particular type of site drawing. A job drawing having 000 as the last group of digits is an index of site job drawings. Some of the dash 2-digit numbered drawings are:

- a. -17 Block Diagram Ground Radio and TTY
- b. -18 PBX and Site Intercom
- c. -30 Key Sheet for 112A Key Equipment

Some of the dash 3-digit drawing numbers show

the location of the equipment on the floor (floor plan drawings), arrangement of equipment on a relay rack (front equipment drawings), fuse-board equipment, simplified block schematic drawings for the power plant, etc.

The dash 4-digit drawing numbers show the wiring lists for the various equipment units by line numbers or for portable test equipment.

Standard drawing numbers are prefixed by SD, meaning schematic drawing. The suffix following the drawing number indicates the sheet number of a particular group of drawings. -012 means this is the second sheet of a group.

Generally a circuit description (CD) pamphlet accompanies each schematic drawing (SD) and they both have the same number. The CD is a written explanation of the circuit operation.

Section 18 of MG-102, *Plant Operating and Maintenance Procedure*, provides general information regarding all types of drawings used in the project.

### 5.2 DRAWING INDEX

Table XIV is a drawing index for Atlantic Ship, Kano, Zanzibar, and Indian Ocean Ship sites.

TABLE XIV  
DRAWING INDEX

	<i>Atlantic Ship</i>	<i>Kano</i>	<i>Zanzibar</i>	<i>Indian Ocean Ship</i>
1. Index of Job Drawings	T-6G03-000	T-6G05-000	T-6G06-000	T-6G07-000
2. System Functional Diagram	T-6G03-1	T-6G05-1	T-6G06-1	T-6G07-1
3. Site Equipment Block Diagram Ground Radio and TTY	T-6G03-17	T-6G05-17	T-6G06-17	T-6G07-17
4. Site Equipment, Block Diagram, Power Distribution, Communications, Control, Transmitter Areas	T-6G03-21	T-6G05-21	T-6G06-21	T-6G07-21

TABLE XIV DRAWING INDEX (Continued)

	<i>Atlantic Ship</i>	<i>Kano</i>	<i>Zanzibar</i>	<i>Indian Ocean Ship</i>
5. Site Equipment, Block Diagram, Power Distribution Point-to-Point Transmitter Areas	T-6G03-24	T-6G05-24	T-6G06-24	T-6G07-24
6. Floor Plan HF Radio and Telemetry Room, Instrumentation Area (Ship Control Area)	T-6G03-101	T-6G05-101	T-6G06-101	T-6G07-101
7. Floor Plan HF Radio Transmitting Room (Tween Deck Area on Ship Sites)	T-6G03-102	T-6G05-102	T-6G06-102	T-6G07-102
8. Floor Plan—Control Area		T-6G05-103	T-6G06-103	
9. Wiring List	T-6G03-1830	T-6G05-1830	T-6G06-1830	T-6G07-1830
10. Relay Rack Equipment	T-6G03-172			T-6G03-172
11. Relay Rack Equipment Point-to-Point Receiver Building		T-6G05-138	T-6G06-138	
12. Relay Rack Equipment Point-to-Point Transmitter Building		T-6G05-139	T-6G06-139	
13. Facility Layout Point-to-Point Radio	T-6G03-386	T-6G05-386	T-6G06-386	T-6G07-386
14. Coax Cabling	T-6G03-385	T-6G05-385	T-6G06-385	T-6G07-385

*References:*

Equipment Specification A Section—Installation B Section—Material	43003-183	43005-183	43006-183	43007-183 (Radio)
	-284	-284	-284	-284 (Antenna)
	-147	-147	-147	-147 (Test Equipment)
	-5052	-5052	-5052	-5052 (Spare Parts)

DP-11197, (DDR-6 Modification)—all sites

MS-108, *Teletypewriter*MS-121, *Outside Plant*MS-109, *Intrasite PBX and Intercom*

TABLE XIV DRAWING INDEX (Continued)

	<i>Atlantic Ship</i>	<i>Kano</i>	<i>Zanzibar</i>	<i>Indian Ocean Ship</i>
<i>References (continued):</i>				
DP-11152, (Discone-Cage Antenna)—ship sites only				
DP-11147, (Antenna Details)—ship sites only				
DP-11148, (Shipboard Antenna)—ship sites only				
DP-11149, Conical Monopole Antenna—ship sites only				
DP-11217, Transmitter Interconnections				
DP-11218, Receiver Interconnections				
MG-102, <i>Plant Operating and Maintenance Procedures</i>				
MO-101R, <i>Remote Site Operations Procedures</i>				

## SECTION 6. MISSION CHECK LISTS

### 6.1 GENERAL INFORMATION

Sections 1 through 6 of this manual present information required to operate and maintain the HF radio point-to-point communications system. This section describes the check lists to be used in determining the equipment status prior to a scheduled mission.

Daily, as during the entire mission, the radio operators should keep the radio equipment operating at peak efficiency, change frequency when necessary, make the required entries in logs, and report any significant change in equipment status to the M&O supervisor.

MO-101R, *Remote Site Operations Procedures*, outlines procedures which the M&O personnel should perform during the Mercury mission. This will be supplemented by an operational directive which will key the mission as to time, frequency, etc. From these items, the M&O supervisor will cue in the procedures to be followed by the various groups. The system check lists described in this section will be used in this portion of the operation.

### 6.2 CHECK LIST DESCRIPTION

System tests made during the countdown period will be performed in accordance with these check lists. The check lists are contained in the detailed system test and the brief system test. For the HF radio point-to-point communications system they are DST-107 and BST-107. These tests consist of two major parts, the check list, which can be used alone, and the test procedures which explain each test in detail. These check lists contain references to the test procedures.

Detailed system tests are more comprehensive and check the major components of the HF radio point-to-point communications system for proper and satisfactory performance. It is intended that this test be performed once during the countdown period. The brief system test is a rapid check determining system over-all performance and is intended to be performed on a continuing basis after the satisfactory completion of the detailed system test. Both check lists contain checks of the intrasite UHF radio at Zanzibar in addition to the HF Radio point-to-point communications system.

### 6.3 INSTRUCTIONS FOR MAKING OUT FORMS

- a. The technician making the test will write his name on the line provided.
- b. Enter the local date, using numbers for day, month, year, in the following manner: 31/12/60 to indicate December 31, 1960.
- c. Enter the time the test is made as T-33 hrs for 33 hours prior to lift-off time. This will be specified for each mission in the supplemental operating directive.
- d. Complete all section for this site. If all readings are within limits, a GREEN condition is indicated. If a test does not meet the limits, a NON-GREEN condition is indicated and appropriate action should be taken to bring the individual equipment within limits. When this is accomplished a GREEN status is then indicated.